



88006399

FINAL REPORT

EVALUATION OF THE PELONCILLO AND ALAMO HUECO MOUNTAINS, NEW MEXICO AS POTENTIAL DESERT BIGHORN HABITAT

U.S. Department of the Interior — Bureau of Land Management
Contract No. 1/A-512-CT7-91

Prepared by:
Andrew V. Sandoval
Desert Bighorn Sheep Project Leader
New Mexico Department of Game and Fish

February 1982

Encl. 1

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

Enclosure -- Information memorandum NM-82-123

8515085

88000399

QL

737

453

521

FINAL REPORT

EVALUATION OF THE PELONCILLO AND ALAMO HUECO MOUNTAINS,

NEW MEXICO AS POTENTIAL DESERT BIGHORN HABITAT

U.S. Department of the Interior - Bureau of Land Management
Contract No. 1/A-512-CT7-91

Prepared by:

Andrew V. Sandoval

Desert Bighorn Sheep Project Leader

New Mexico Department of Game and Fish

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

February 1982

FINAL REPORT

REPORT OF THE COMMISSIONER OF THE GENERAL LAND OFFICE
ON THE PROGRESS OF THE SURVEY OF THE PUBLIC LANDS
IN THE TERRITORY OF ARIZONA, DURING THE YEAR 1890

ALBUQUERQUE, N. M.:
PUBLISHED BY THE TERRITORIAL GOVERNMENT,
1891.

To Faust el Lobo Silvestre (1974-1981),
my long-haired German shepherd, for his
welcomed companionship on many lonely
days that only man's best friend can
provide. Without Faust, my backcountry
trips would never have been the success-
ful and rewarding experiences they were.

1870-1871
The first of the year was a very dry one, and the crops were much injured. The weather was very hot, and the crops were much injured. The weather was very hot, and the crops were much injured. The weather was very hot, and the crops were much injured.

ABSTRACT

EVALUATION OF THE PELONCILLO AND ALAMO HUECO MOUNTAINS, NEW MEXICO AS POTENTIAL DESERT BIGHORN HABITAT

The Bureau of Land Management, U.S. Forest Service, and the New Mexico Department of Game and Fish initiated studies to determine which areas of historic desert bighorn sheep (Ovis canadensis mexicana) range in New Mexico have the highest potential for the re-establishment of bighorn populations, and to evaluate and rank selected areas in order of suitability as desert bighorn habitat. This study consisted of two phases. In Phase I, 16 historic desert bighorn sheep ranges were qualitatively evaluated in order of suitability as bighorn habitat (Sandoval 1979a). In Phase II, the Peloncillo and Alamo Hueco Mountains were quantitatively described in terms of size, topography, vegetation, water availability and human use. The habitat was described using a computer for data storage, analysis, and retrieval. Potential bighorn habitat was based on comparative data obtained during previous studies of indigenous and reintroduced bighorn populations in the San Andres and Big Hatchet Mountains.

Although the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains are characterized by rugged terrain and reflect similar climatic trends, they do not exhibit similar floral and faunal diversity. Similarity index values indicated that the San Andres and Big Hatchets are most similar in the availability of vegetation and slope: The Peloncillo and Alamo Hueco Mountains are most similar in elevation and exposure. The sedimentary parent material of the San Andres and Big Hatchets produce more shrubs than grasses. The

igneous soils of the Peloncillo and Alamo Huecos support relatively homogenous grasslands. Based on characteristics of occupied habitat in the San Andres and Big Hatchet Mountains, a total of 444 km² (171 mi.²) was identified as potential bighorn habitat in the Peloncillo Mountains. Suitable bighorn habitat has a mean elevation of 1,622 m (5,322 ft.), with a range of 1,512-2,112 m (4,961-6,928 ft.). East, northeast, and southeast exposures accounted for 23 percent of the habitat. Slope gradients ≥ 10 percent comprised 33 percent of the habitat. Seven habitat/vegetation types were identified. Vegetation analysis indicated an overall ground cover of 43 percent. The relative botanical composition was 47 percent grasses, 46 percent shrubs, and 8 percent forbs. Total herbaceous forage production was 336 kg/ha (376 lbs./ac.). Carrying capacity estimates based on forage production, consumption rates, and allowable utilization was 1,037 bighorn sheep. Forty-two water sources were evaluated in terms of availability, topography, and vegetative communities. Twenty-six percent of these water sources provide water year-long. Water sources are situated at a mean elevation of 1,585 m (5,200 ft.), and at a mean slope of 17 percent. Fifty-one percent are found on northeast, east, and southeast exposures. The potential for human disturbance to bighorn sheep was classified as moderate to high because of good access to currently occupied and/or suitable habitat. Some overlap in the distribution of cattle and deer (Odocoileus spp.) with potential and occupied bighorn habitat exists, and overgrazing is moderate to high in some areas.

A bighorn sheep transplant was initiated on BLM administered lands in the Peloncillo Mountains. In June 1981, 28 bighorn (10 ewes, 10 rams,

and 8 lambs) were released from a temporary holding paddock. Ten rams, and 5 of 8 lambs died by late summer. Clinical symptoms and laboratory results indicated chronic bronchopneumonia as the cause of death. The population was supplemented twice with an additional 6 rams. Other mortality factors and extensive dispersal have reduced the population to 13 (7 ewes, 3 lambs, and 3 rams). The southern portion of the study area within the Coronado National Forest was classified as marginal bighorn habitat, and no suitable release sites were identified.

A total of 210 km² (81 mi.²) was identified as potential bighorn habitat in the Alamo Hueco Mountains. Potential bighorn habitat has a mean elevation of 1,573 m (5,162 ft.), with a range of 1,219-1,956 m (4,000-6,416 ft.). Northeast, east, and southeast exposures accounted for 23 percent of the habitat. Slope gradients $\geq$ 10 percent comprised 39 percent of the habitat. Six habitat/vegetation were identified. Vegetation analysis revealed an overall ground cover of 35 percent. The relative botanical composition was 47 percent grasses, 38 percent shrubs, and 15 percent forbs. Total herbaceous forage production was 241 kg/ha (270 lbs./ac.). The carrying capacity estimate was 573 bighorn sheep. Fifty-eight percent of the water sources (n = 24) were identified as dependable perennial sources. Water sources are situated at a mean elevation of 1,581 m (5,186 ft.), and at a mean slope of 16 percent. Thirty-four percent of these water sources are situated on east and southeast exposures. Presently, all public access into the Alamo Huecos is prohibited; consequently, the potential for human disturbance to bighorn sheep was classified as low. Livestock grazing was commensurable

with forage availability. The Alamo Hueco and Big Hatchet Mountains have a high economic potential for oil and gas production, which might have a detrimental effect on existing bighorn populations and future reintroduction efforts. A bighorn sheep transplant site was identified in Cottonwood Canyon, on the northeast side of the mountain range. To enhance the possibility of the release site becoming a traditional lambing area and to minimize dispersal of sheep into less desirable areas, a paddock-type release is proposed.

ACKNOWLEDGEMENTS

This study would not have been accomplished without the cooperation and assistance of numerous organizations and individuals. The study was a cooperative effort between the U.S. Department of the Interior - Bureau of Land Management, the U.S. Department of Agriculture - Forest Service, and the New Mexico Department of Game and Fish.

I wish to acknowledge the many people of these organizations who assisted in many ways and provided valuable support. Special thanks to Mr. Lee Upham - BLM State Office, Mr. Joseph Torres and Mr. Ken Holmes - BLM Las Cruces District Office, Mr. Art Renfro - U.S. Forest Service Region 3 Office, Mr. Jim Johnson, Dr. John Hubbard, and Mr. Greg Schmitt with the New Mexico Department of Game and Fish, and Ms. Amy Elenowitz - New Mexico State University.

Special thanks to Mr. Walt Snyder, New Mexico Department of Game and Fish for extreme patience during the preparation of this report. Dr. N. Scott Urquhart, New Mexico State University, provided technical assistance in data analysis. Ms. Nancy Gilbertson, wildlife student at New Mexico State University assisted in reading vegetation transects.

Also deserving thanks are to Ms. Lydia Duran for patiently typing the manuscript. Ms. Summer Brooks assisted with the graphics. Duplicating Services, New Mexico State University printed the report.

The efforts of many other individuals also contributed to the success of this study, but the list is much too long for mention here of the specific contributions of each one. However, I am very grateful to all of them for their help.

TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	xii
LIST OF FIGURES	xv
CHAPTER	
I INTRODUCTION	1
Objectives	4
Methods and Materials	5
II PELONCILLO MOUNTAINS	9
Description of Study Area	9
Location	9
Climate	9
Geology	11
Soils	11
Flora	14
Fauna	15
Water availability	17
History of bighorn occupancy	18
Land status and use	20
Bighorn Sheep Reintroduction	22
Introduction	22
Capture of ewes and transplant	22
Paddock construction	23
Predator control	26
Ewe mortality	27
Lamb production	27

	<u>Page</u>
Ram transplant	27
Release from the paddock	28
Ram die-off	28
Treatment	30
III ALAMO HUECO MOUNTAINS	31
Description of Study Area	31
Location	31
Climate	31
Geology	34
Soils	34
Flora	36
Fauna	36
Water availability	38
History of bighorn occupancy	38
Land status and use	40
IV HABITAT AVAILABILITY	42
Peloncillo Mountains	42
Elevation	42
Exposure	42
Slope	42
Vegetation	46
Forage production and animal abundance	46
Water	46
Alamo Hueco Mountains	55
Elevation	55

	<u>Page</u>
Exposure	55
Slope	55
Vegetation	59
Forage production and animal abundance	59
Water	59
V CARRYING CAPACITY ESTIMATES	66
Introduction	66
Peloncillo Mountains	67
Alamo Hueco Mountains	67
Discussion	70
VI RESULTS AND DISCUSSION	72
Introduction	72
Habitat Comparisons	74
Topographic homogeneity	74
Elevation	76
Exposure	78
Slope	81
Vegetation	84
Water	92
Human use	93
VII MANAGEMENT PROGRAMS	98
Introduction	98
Recommendations	98

	<u>Page</u>
LITERATURE CITED	104
APPENDICES	
A List of plants referred to in report or identified from the Peloncillo Mountains, New Mexico	108
B Endangered species known to occur in/or reported from the Peloncillo Mountains, New Mexico	112
C Vegetation analysis, Peloncillo Mountains, New Mexico	114
D List of plants referred to in report or identified from the Alamo Hueco Mountains . .	117
E Vegetation analysis, Alamo Hueco Mountains, New Mexico	121

LIST OF TABLES

<u>Table No.</u>		<u>Page</u>
1	Relative suitability of historic desert bighorn sheep ranges as potential transplant sites (Sandoval 1979a)	6
2	Land status in the area intensively evaluated as desert bighorn habitat, Peloncillo Mountains, New Mexico	20
3	Data on desert bighorn sheep ewes transplanted on the Peloncillo Mountains, Hidalgo County, New Mexico, November 27, 1980	24
4	Desert bighorn sheep observed in the Alamo Hueco Mountains, New Mexico, and vicinity, 1893-1981	40
5	Land status in the Alamo Hueco Mountains, New Mexico	40
6	Availability of elevations in the Peloncillo Mountains, New Mexico	43
7	Availability of exposures in the Peloncillo Mountains, New Mexico	44
8	Availability of slope in the Peloncillo Mountains, New Mexico	45
9	Relative size and mean elevation in meters (feet) of habitat types in the Peloncillo Mountains, New Mexico	47
10	Vegetative cover and composition in the Peloncillo Mountains, New Mexico	48
11	Forage production and animal abundance relative to habitat types, Peloncillo Mountains, New Mexico	49
12	Water availability in the Peloncillo Mountains, New Mexico	50
13	Water availability relative to physiographic characteristics in the Peloncillo Mountains, New Mexico	53

<u>Table No.</u>		<u>Page</u>
14	Availability of elevation in the Alamo Hueco Mountains, New Mexico	56
15	Availability of exposures in the Alamo Hueco Mountains, New Mexico	57
16	Availability of slope in the Alamo Hueco Mountains, New Mexico	58
17	Relative size and mean elevation in meters (feet) of habitat types, Alamo Hueco Mountains, New Mexico	60
18	Vegetative cover and composition in the Alamo Hueco Mountains, New Mexico	61
19	Forage production and animal abundance relative to habitat types, Alamo Hueco Mountains, New Mexico	62
20	Water availability in the Alamo Hueco Mountains, New Mexico :	63
21	Water availability relative to physiographic characteristics in the Alamo Hueco Mountains, New Mexico	65
22	Carrying capacity estimates based on herbaceous forage production, consumption rates, and allowable utilization, Peloncillo Mountains, New Mexico	68
23	Carrying capacity estimates based on herbaceous forage production, consumption rates, and allowable utilization, Alamo Hueco Mountains, New Mexico	69
24	Comparison of the topographic homogeneity of the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico (numbers in table represent distribution of R^2 values expressed as percent)	75
25	Comparison of the availability of elevations in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico	77

<u>Table No.</u>		<u>Page</u>
26	Measure of similarity of elevational availability in the San Andres, Big Hatchet, Alamo Hueco, and Peloncillo Mountains, New Mexico . .	79
27	Comparison of the availability of exposures in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico	80
28	Measure of similarity of exposure availability in the San Andres, Big Hatchet, Alamo Hueco, and Peloncillo Mountains, New Mexico	82
29	Comparison of the availability of slope in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico	83
30	Measure of similarity of slope availability in the San Andres, Big Hatchet, Alamo Hueco, and Peloncillo Mountains, New Mexico	85
31	Comparison of vegetative cover and relative composition in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico	89
32	Comparison of vegetative species composition in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico (based on Ellenberg's Similarity Index)	91
33	Composite comparison of major habitat components between the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico (based on Similarity Index Values).	91

LIST OF FIGURES

<u>Figure No.</u>		<u>Page</u>
1	Past and present distribution of Mexican bighorn sheep in New Mexico	2
2	Map of the study area in the Peloncillo Mountains, New Mexico showing place names, and the 10,000 m Universal Transverse Mercator Grid System	10
3	Mean monthly precipitation and temperatures for Rodeo, New Mexico, 1966-1976	12
4	The Peloncillo Mountains are composed of marine carbonate rocks that overlie granite. The sedimentary rocks are intruded and metamorphosed by igneous rocks	13
5	Bedrock occurs as extensive vertical exposures throughout much of the Peloncillo Mountains . .	13
6	Grass/desert shrub community in foreground and mixed shrub/grass type in background - Wood Canyon, Peloncillo Mountains	16
7	Localized stands of piñon and juniper occur on north exposures and protected sites intermingled between rock outcrops - Gray Peak, Peloncillo Mountains	16
8	Diagram showing cross section of holding paddock	25
9	Map of the study area in the Alamo Hueco Mountains, New Mexico showing place names, and the 10,000 m Universal Transverse Mercator Grid System	32
10	The topography along the northwest, north, and northeast flank of the Alamo Hueco Mountains is characterized by numerous outcrops of bedrock forming vertical cliffs	33
11	The southside of the Alamo Hueco Mountains (background) consists of undulating topography, bisected by numerous drainages	33

<u>Figure No.</u>		<u>Page</u>
12	Mean monthly precipitation and temperatures for Hachita, New Mexico, 1966-1976	35
13	A relatively homogenous grassland community near the head of Emory Canyon, Alamo Hueco Mountains.	37
14	A mixed shrub/grass type is found within canyon bottoms, on adjacent protected slopes, and below cliffs - Cottonwood Canyon, Alamo Hueco Mountains	37

CHAPTER I

INTRODUCTION

Historically, desert bighorn (Ovis canadensis) occurred in sizable numbers from Nevada southward to Coahuila, Mexico, and from western Texas, southern New Mexico and Arizona, western Colorado, and Utah westward to California. In New Mexico, desert bighorn were found in the arid and rugged mountain ranges in the southcentral and southwestern portion of the state (Figure 1) (Sandoval 1979b).

Due to the increasing human population and associated land use practices during the latter part of the 19th century, desert bighorn fared badly. Their numbers dwindled rapidly along with a corresponding loss of habitat. The decline, and in many areas their extirpation, has been due to indiscriminate activities of man, competition and diseases introduced by other ungulates, and illegal harvest. Desert bighorn have disappeared from all but two of their historic ranges, and are presently classified as a state endangered species.

In an effort to restock historic range and to supplement existing remnant populations, the New Mexico Department of Game and Fish initiated a program for propagating desert bighorn. In January 1972, 5 bighorn ewes were captured in Sonora, Mexico. This area was selected because the sheep in this area are of common ancestry with the sheep indigenous to New Mexico. Within a month after their release into an enclosure at the Red Rock Wildlife Experimental Area, each of the ewes lambed. The captive population was supplemented

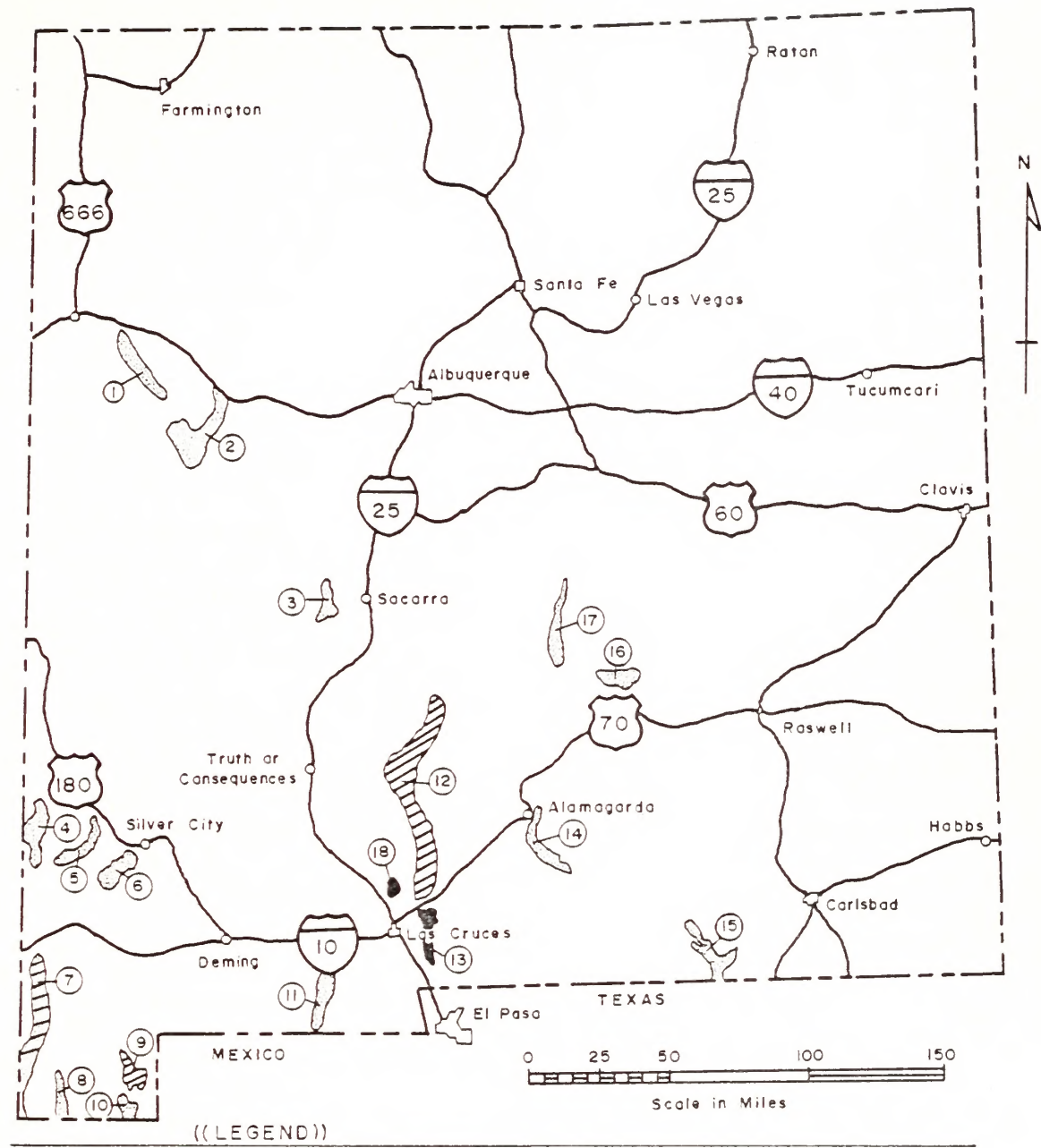


Figure 1. Past and present distribution of Mexican bighorn sheep in New Mexico.

in 1972 with 5 ewes and 3 rams, and again in 1975 with an additional 8 ewes taken from the San Andres Mountains. At the date of this report, December 1981, 34 bighorn remain confined at Red Rock: 12 adult ewes, 6 1.5-year-old ewes, 11 lambs and 5 rams.

During the Fall of 1978, scabies mites (Psoroptes ovis Hering) were discovered in desert bighorn from the San Andres Mountains. Intensive ground and aerial surveys revealed that the sheep population decreased from a pre-epizootic estimate of 200 to less than 75 within a one-year period (Sandoval 1980).

In November 1979, 28 bighorn (23 ewes and 5 rams) from the San Andres Mountains were confined in a separate enclosure at Red Rock for recovery from the scabies epizootic. During Spring 1980, 7 lambs were born to the San Andres sheep. A die-off attributed to blue-tongue reduced the San Andres captive population to 19 animals by July 1980. The animals were then captured and inoculated against blue-tongue. In January 1981, 14 bighorn (9 ewes, 4 rams, 1 lamb) were captured at Red Rock and returned to the San Andres Mountains. Two rams died enroute to the release site.

Due to the recent scabies epizootic and corresponding loss of the San Andres bighorn population, the current situation in New Mexico is particularly precarious. Currently, less than 120 animals remain in the state, of which 30 percent are in captivity. Until recently, the San Andres herd was the only indigenous population in a viable condition. The only other indigenous population found in the Big Hatchet Mountains was headed towards extinction until the Department of Game and Fish transplanted sheep there from Red Rock in January 1978.

The loss of the San Andres bighorn as a viable population dictates that great emphasis will have to be placed on an aggressive transplant program. To this end, the Department of Game and Fish and the Bureau of Land Management completed a preliminary evaluation of historic desert bighorn range. The method for evaluating habitat factors that affect desert bighorn was based on environmental characteristics and degree of human use. The method consisted of a series of parameters which, in combination, subjectively determined the suitability of an area as a potential release site. These parameters were 1) natural topography, 2) vegetation type, 3) water-type and use, 4) precipitation, 5) evaporation, and 6) human use. Each component was assigned a numerical value in relation to its influence in the overall criteria that constitutes potential desert bighorn habitat. The values were assigned in such a way that human use (actual and potential) would be favored in the less precipitous habitat and bighorn would be favored in the areas that are vital to their existence (Sandoval 1979a).

Objectives

Based on the availability of suitable habitat, minimal human disturbance, and the unlikely invasion by exotics, Sandoval (1979a) recommended the Peloncillo and Alamo Hueco Mountains for more intensive studies to determine their full potential for perpetuating populations of desert bighorn sheep. This report represents a quantitative analysis of these areas' potential as desert bighorn habitat. Suitability as bighorn habitat is based on similarity

indices with comparative data developed during the studies of the indigenous bighorn population in the San Andres Mountains (Sandoval 1979b) and Big Hatchet Mountains (Watts 1979, Bavin 1981).

Methods and Materials

This study consisted of two phases. In Phase I, 16 historic bighorn sheep ranges were qualitatively evaluated to determine their suitability for the re-establishment of desert bighorn populations (Table 1) (Sandoval 1979a). Two areas were then selected for more intensive examination. In Phase II, the Peloncillo and Alamo Hueco Mountains were quantitatively described in terms of size, topography, vegetation, water availability and human use.

In order to objectively describe potential bighorn habitat, a computerized technique for habitat evaluation was employed. The habitat was described in quantitative terms using an AMDAHL-V-5 computer for data storage, analysis and retrieval. Outlined maps of the study areas were constructed in computer terminology, and the various parameters that constitute bighorn habitat were added to the base maps using computerized overlays. One overlay per parameter was constructed showing elevation, topography, habitat types, and water sources. This approach allowed analysis of each parameter separately or in any desired combination.

Elevation data are available for the entire United States from the National Cartographic Information Center, Geological Survey, Reston, Virginia. These data are supplied in a variety of forms, but the most convenient is on magnetic computer tape with 1,600 bits

Table 1. Relative suitability of historic desert bighorn sheep ranges as potential transplant sites (Sandoval 1979a).

Area	Size (mi ²)	Available habitat ^a	Competition ^b	Land status ^c
Alamo Hueco Mtns.	66	35	Low	57
Big Hatchet Mtns.	89	27	High (livestock grazing)	99
Burro Mtns.-Gila Middle Box	90	38	High (Rocky Mtn. bighorn)	68
Caballo Mtns.	82	5	High (human use and livestock grazing)	93
Cooke Range	102	14	Moderate (ibex and livestock grazing)	74
Florida Mtns.	44	41	Occupied (ibex)	87
Fra Cristobal Mtns.	61	32	Low	0
Guadalupe Mtns.	182	55	Occupied (aoudads and human use)	95
Ladron Mtns.	54	35	Moderate (feral goats)	65
Little Hatchet Mtns.	60	7	High (livestock grazing and human use)	90
Magdalena Mtns.	146	12	High (human use)	91
Malpais	254	2	Low	35
Peloncillo Mtns.	339	24	Moderate, (livestock grazing)	71
Sacramento West Escarpment	101	27	Occupied (aoudads and feral goats)	70
San Mateo Mtns.	29	24	Moderate (human use)	96
West Potrillo Mtns.	134	0	Moderate (ibex)	100

^apercent of total area classified good to optimum habitat.

^bCompetition includes degree of human use and the possibility of invasion by nonindigenous or conspecific wildlife. Nonindigenous wildlife includes aoudads, ibex and feral goats, while conspecific includes Rocky Mountain bighorn sheep.

^cPercent of total area administered by Federal or State Agencies.

per 2.54 cm (1 in.). These elevations relate to the 1:250,000 UTM 1°x2° series maps. Elevations are obtained for a grid of points 0.0254 cm (0.01 in.) apart, a distance which corresponds to 63.49 m (208.33 ft.) on the ground. Each elevation and its surrounding nine elevation points were fitted by least squares plane using multiple regression (refer to Urquhart 1977). Slope and exposure were determined and evaluated from these elevation points.

Vegetation studies were conducted to determine species composition and density. Data on composition of herbaceous vegetation were obtained utilizing a modification of the step-point sampling technique (Evans and Love 1957). Estimates of total ground cover (density) of herbaceous plants were obtained with the use of a square-foot frame subdivided into four 15 cm (6 in.) squares. Measurements of shrubs and half-shrubs densities were obtained by the variable plot method (Cooper 1963), using a hand held angle gauge.

Delineation of habitat types was based on vegetative associations and topography. Habitat types were coded on a 200 m (656 ft.) grid. After the elevation grid had been constructed from the digital terrain tapes, and the two coordinate systems corresponded, the vegetation type nearest the selected points was used as the vegetation for that plot. These vegetation plots measure 190.5 x 190.5 m (625 x 625 ft.), or approximately 3.6 ha (9 ac.).

The water source overlays were constructed from data gathered in the field, and by reviewing topographic maps. The location of all known water sources was designated by the corresponding grid

coordinates and entered on computerized maps as described for the other parameters. Water availability was determined from data gathered in the field and by interviewing local ranchers.

Relative degree of occupancy by cattle, deer (Odocoileus spp.) and rabbits (Sylvilagus spp., Lepus spp.) was estimated from counts of fecal groups in 1/100th acre plots. Fecal group plots were established on each 25th observation point. All readily identifiable pellet groups were tallied regardless of age due to the difficulty in distinguishing between current years, and older pellets. Groups on the edge of the plot were counted only when half or more of the group occurred inside the plot. The total number of pellet groups per acre was computed for each animal species involved. Javalina (Dicotyles tajacu) droppings occasionally were encountered but were not tallied because their density was too low to be of significance.

Herbaceous air dried forage weight was estimated in each of 10-4 m (13.25 ft.) diameter circular plots spaced at 6 m (20 ft.) intervals along each transect. Before collecting field data, several hours were spent in learning to estimate forage production accurately. Forage weight was converted from grams/plot to pounds/acre by multiplying by 100.

CHAPTER II

PELONCILLO MOUNTAINS

Description of Study Area

Location. The study area was located in the central portion of the Peloncillo Mountains, Hidalgo County, in extreme southwestern New Mexico ($108^{\circ} 58' - 109^{\circ} 03' \text{ W} \times 31^{\circ} 35' - 31^{\circ} 58' \text{ N}$). The Peloncillo Mountains are a narrow range rising 305-457 m (1,000-1,500 ft.) above the Animas Valley on the east and the San Simon Valley on the west. The mountain range is concave to the west and extends north from the border with the Republic of Mexico for 120 km (75 mi.) on both sides of the New Mexico-Arizona line (Figure 2).

The mountains are bisected by Interstate 10 at Stein's Pass (1,326m - 4,350 ft.); by U.S. 80 at Granite Gap (1,365m - 4,480 ft.); by State Road 9 at Antelope Pass (1,351m - 4,435 ft.); and by State Road 338 at Geronimo Gap (1,813m - 5,950 ft.).

The Peloncillo Mountains reach a maximum elevation of 2,109 m (6,928 ft.) above sea level at Gray Peak. The more prominent peaks include Black Point (1,971m - 6,467 ft.), Guadalupe Mountain (1,966m - 6,450 ft.), Mount Baldy (1,920m - 6,300 ft.), and Bunk Robinson Peak (1,902m - 6,241 ft.).

Climate. Long-term weather data for the Peloncillo Mountains are lacking. The nearest weather recording station is at Rodeo (1,255m - 4,118 ft.), located in the San Simon Valley 9.6 km (6 mi.) west of the mountain range. The mean annual precipitation for Rodeo

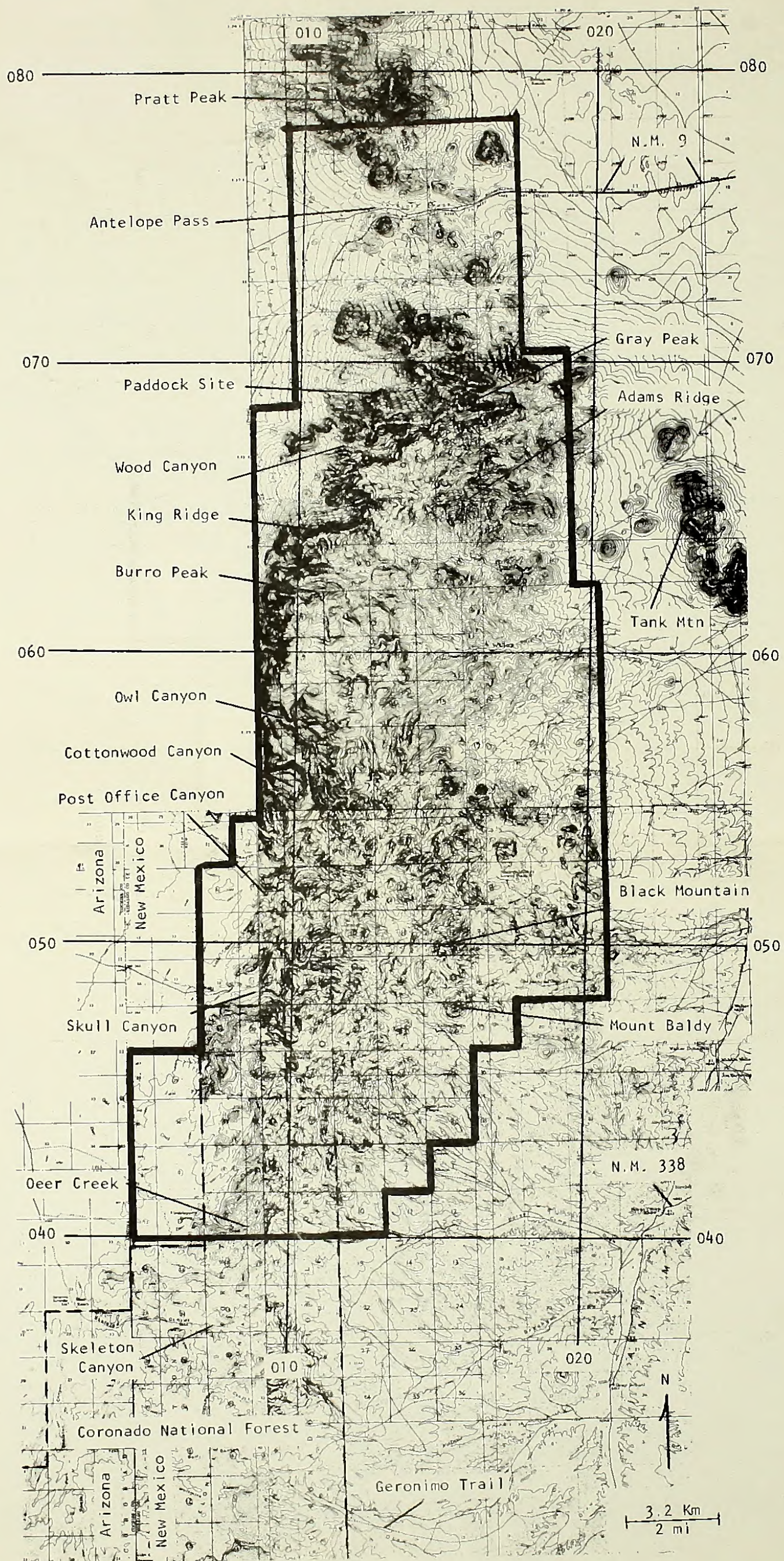


Figure 2. Map of the study area in the Peloncillo Mountains, New Mexico showing place names, and the 10,000 meter Universal Transverse Mercator Grid System.

is 27.6 cm (10.9 in.). Sixty-six percent of the precipitation occurs between July and October. July receives the greatest amount with a mean of 5.8 cm (2.3 in.). April receives the least amount with a mean of .30 cm (.12 in.) (Figure 3).

The mean annual temperature for Rodeo is 15.1° C (58.9° F). January is the coldest month with a mean temperature of 6.2° C (43.1° F). July is the warmest month with a mean maximum temperature of 26.8° C (79.9° F) (Figure 3).

These data do not necessarily reflect climatic conditions on the mountain range, particularly at higher elevations and in the southern portion. The southern Peloncillo range contains the higher peaks which intercept more precipitation; between 1976 and 1980, the mean annual precipitation for Guadalupe Canyon averaged 43.25 cm (17.03 in.), with a range of 29.1 cm (11.46 in.) in 1979 to 56.5 cm (22.25 in.) in 1977 (Baltosser 1981).

Geology. The central Peloncillo Mountains consist of Precambrian to middle Tertiary igneous and sedimentary rocks that are overlain to the north and south by middle Tertiary and younger volcanic rocks. The range is predominantly composed of Paleozoic and Mesozoic marine carbonate rocks that overlie Precambrian granite. The sedimentary rocks are intruded and metamorphosed by igneous rocks (Todd et al. 1975) (Figure 4).

Soils. Soils in the Peloncillo Mountains include the Rock Land-Haplargids association, which are developing in a material of igneous origin.

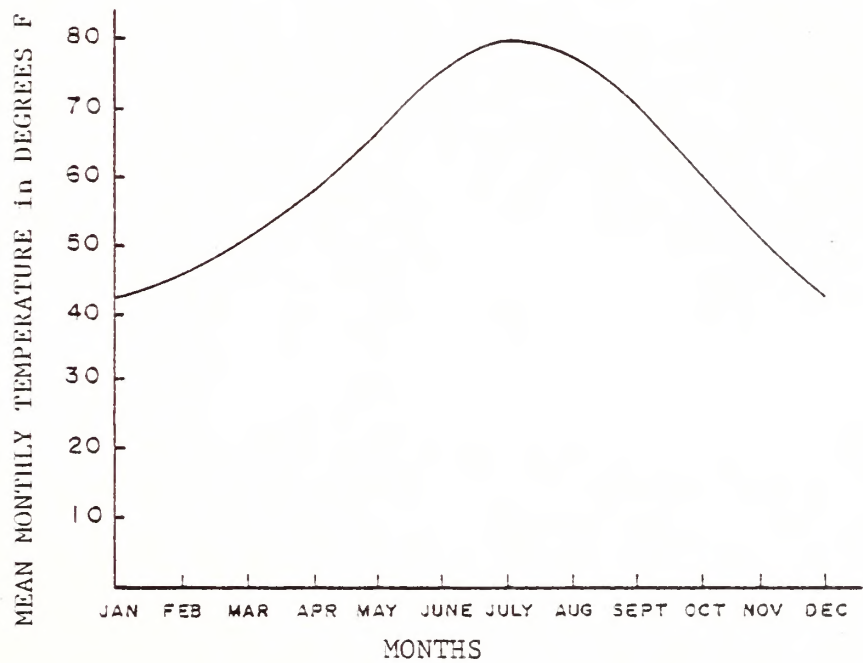
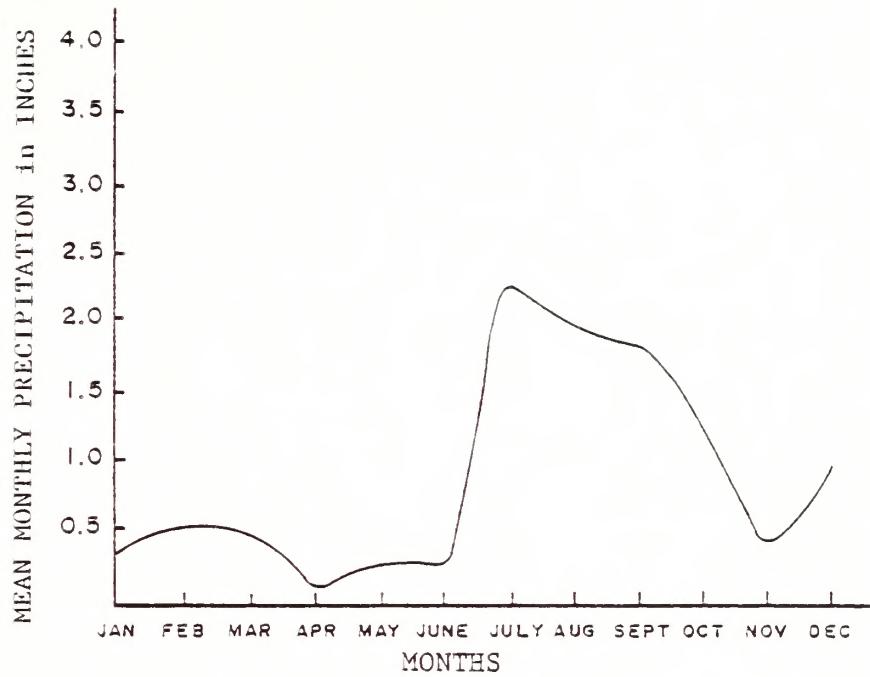


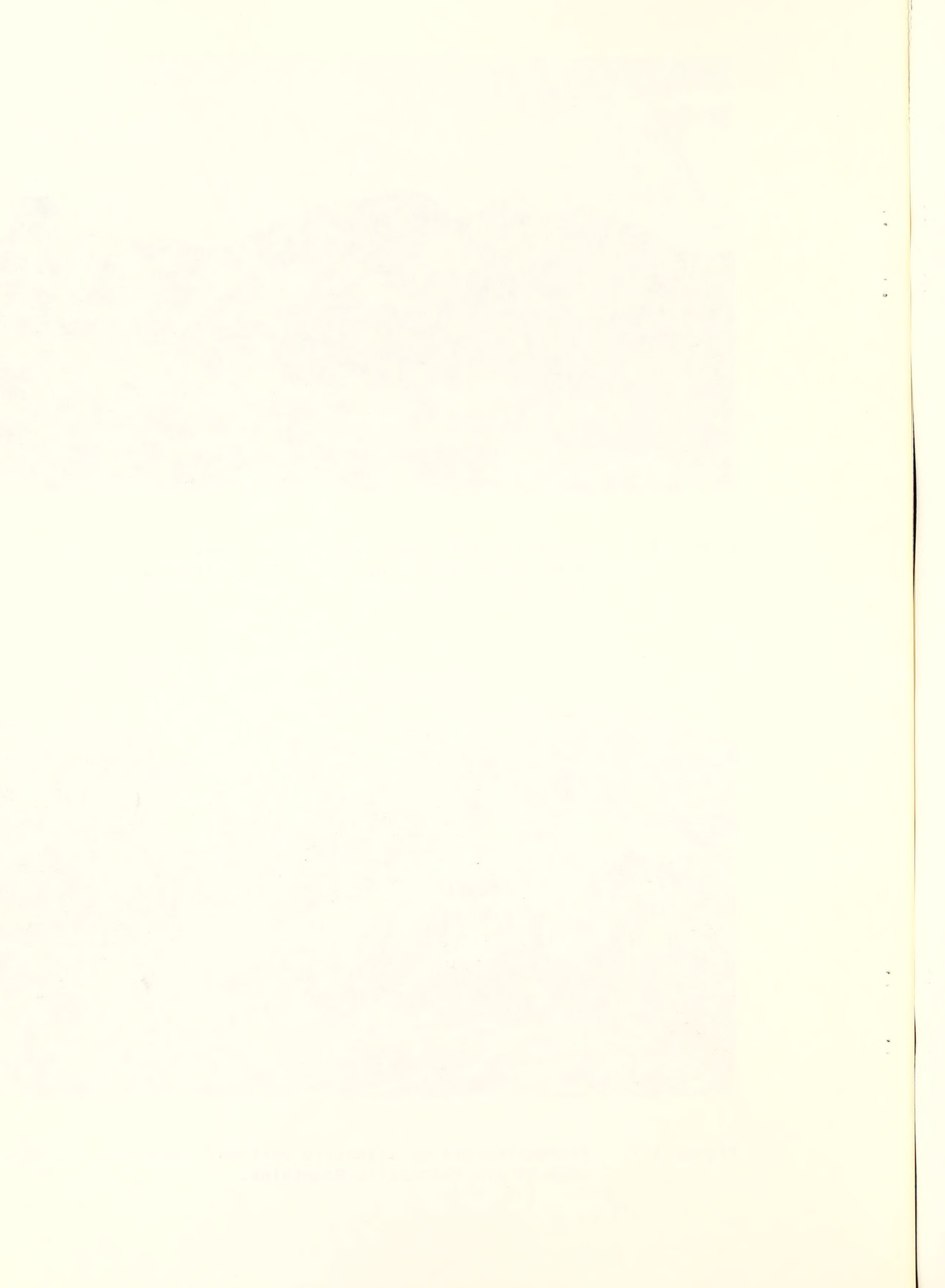
Figure 3. Mean monthly precipitation and temperatures for Rodeo, New Mexico, 1966-1976.



Figure 4. The Peloncillo Mountains are composed of marine carbonate rocks that overlie granite. The sedimentary rocks are intruded and metamorphosed by igneous rocks.



Figure 5. Bedrock occurs as extensive vertical exposures throughout much of the Peloncillo Mountains.



Rock Land is a complex of very shallow soils and rock outcrops. The bedrock occurs as extensive vertical exposures throughout much of the mountain range. In many parts, large amounts of loose rock occur on the surface. A thin mantle of cobbly or stony soil material is usually found between the outcrops of bedrock. Although the intermingled soils are dominantly shallow, small areas of moderately deep soils occur in pockets among the rock outcrops (Maker et al. 1974) (Figure 5).

The Haplargids are usually associated with moderately steep slopes. These soils usually have thin, moderately coarse and medium textured surface layers over moderately well-developed subsoils. Gravel, cobble, and stones frequently occur in both surface and subsurface layers (Maker et al. 1974).

Flora. Life zones represented in the Peloncillo Mountains include the Lower Sonoran, Upper Sonoran and Transition (Merriam 1890). The southern portion of the range is primarily in the Transition Zone. The floristics of this area show a pronounced influence of the Sierra Madres of Mexico. Vegetation is characterized by localized stands of coniferous forest consisting of Pinus leiophylla var. chihuahuana, and Pinus cembroides. The understory consists of several species of oak (Quercus hypoleucoides, Q. reticulata, Q. arizonica, Q. grisea), Cercocarpus montanus, Nolina microcarpa, and Sporobolus spp., Muhlenbergia spp., Croton spp. and Sphaeralcea spp. Plants identified from the Peloncillo Mountains are listed in Appendix A.

Xeric species indicative of the Sonoran Life Zones replace the woodland types in a gradual northern cline, and with a loss of elevation. Two general vegetative communities were recognized; a mixed shrub/grass type occupying sites with deeper soils, moderately steep topography, and higher rainfall; and a grass/desert shrub type associated with steep, rocky slopes, shallow soils, and areas usually receiving ≤ 25.4 cm (10 in.) of precipitation (Figure 6). Localized stands of Pinus cembroides, Juniperus monosperma and J. deppeana occur on north-facing slopes and protected sites within canyon bottoms and intermingled between rock outcrops (Figure 7).

Fauna. The location and orientation of the Peloncillo Mountains provides a natural passage and sanctuary for unique fauna from Mexico into the United States. The great species diversity of fauna and flora creates a special interest in this area for mammalogists, ornithologists, and botanists alike.

Twenty-eight species of mammals, birds, reptiles and amphibians classified as rare, endangered, or peripheral occur in the Peloncillo Mountains and vicinity (Hubbard et al. 1979, Baltosser 1980) (Appendix B). Characteristic mammals that were present during this study include:

- | | |
|--|------------|
| a. Mule deer (<u>Odocoileus hemionus crooki</u>) | common |
| b. Whitetail deer (<u>Odocoileus virginianus cousei</u>) | common |
| c. Javalina (<u>Dicotyles tajacu</u>) | occasional |
| d. Mountain lion (<u>Felis concolor</u>) | common |
| e. Bobcat (<u>Lynx rufus</u>) | common |
| f. Coyote (<u>Canis latrans</u>) | common |

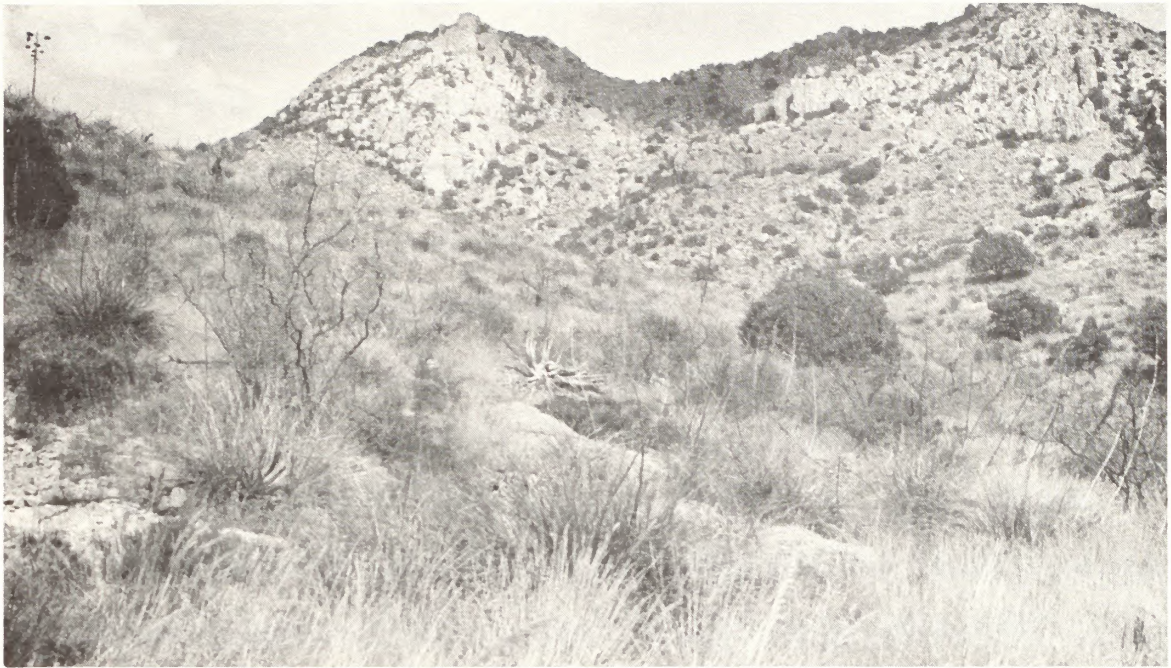


Figure 6. Grass/desert shrub community in foreground and mixed shrub/grass type in background - Wood Canyon, Peloncillo Mountains.



Figure 7. Localized stands of pinon and juniper occur on north exposures and protected sites intermingled between rock outcrops - Gray Peak, Peloncillo Mountains.

Smaller mammals include:

- | | |
|---|------------|
| a. Gray fox (<u>Urocyon cinereoargenteus</u>) | common |
| b. Ringtail cat (<u>Bassariscus astutus</u>) | occasional |
| c. Coatimundi (<u>Nasua narica</u>) | occasional |
| d. Porcupine (<u>Erethizon dorsatum</u>) | occasional |
| e. Cottontail rabbit (<u>Sylvilagus auduboni</u>) | common |
| f. Blacktail jackrabbit (<u>Lepus californicus</u>) | common |
| g. Hognose skunk (<u>Conepatus leuconotus</u>) | common |

Two species of quail were commonly found in the desert riparian communities especially during years of adequate precipitation.

These include scaled quail (Callipepla squamata), and Gambel's quail (Lophortyx gambelli). Mearn's quail (Cyrtonyx montezumae mearnsii) although reported by Bailey (1928) and Campbell (1967) as occurring in the Peloncillo Mountains, were not seen during the course of field work.

Golden eagles (Aquila chrysaetos) nested along the cliffs of the west escarpment. Several species of hawks were frequently seen, including the red-tailed hawk (Buteo jamaicensis), the marsh hawk (Circus cyaneus) and Cooper's hawk (Accipiter cooperii).

Numerous species of reptiles were found during the warm season. The black-tailed rattlesnake (Crotalus molossus), and the banded rock rattlesnake (Crotalus lepidus klauberi) were frequently encountered, necessitating caution while walking in the study area.

Water availability. A total of 41 water sources was located in the area intensively evaluated as desert bighorn habitat (refer

to Chapter IV). The majority of these consist of concrete stock tanks and windmills. Only three naturally-occurring water sources were found (Willy Wright Seep, Cottonwood Spring, and Woodchoppers Spring). During years of above-average precipitation, intermittent flow may be found in Owl and Skull Canyons (Figure 2).

A permanent rain water catchment unit was constructed in Goat Canyon to enhance the possibility of the release site becoming a traditional lambing and summer range for bighorn transplanted on the Peloncillo Mountains (refer to section on Bighorn Sheep Reintroduction). The watering unit is the New Mexico Department of Game and Fish umbrella type, consisting of a 4.9 m (16 ft.) circular collecting apron bolted on top of a corrugated iron storage tank with an off-line floatbox and drinking basin. The unit has a storage capacity of 8,536 l (2,255 gal.). Due to insufficient precipitation during winter 1980 and spring 1981, the unit was supplied twice with approximately 5,678 l (1,500 gal.) of water, utilizing a pumper truck provided by the BLM, Las Cruces District office. At the date of this report, February 1982, the unit was approximately 90 percent full.

History of bighorn occupancy. Historic occurrence of bighorn sheep in the Peloncillo Mountains is based on the location of petroglyphs and pictographs that depict bighorn and early records of explorers and settlers. Known petroglyphs and pictograph sites are located in Skeleton Canyon--in the southern portion of the range, Doubtful Canyon--in the central part of the range, and in the

vicinity of Steeple Rock located in the extreme northern end. These do not provide evidence concerning specific numbers of bighorn, but they do suggest that bighorn were widely distributed throughout the Pelonçillo Mountains.

Many attempts have been made in the past to interpret the significance of rock art relative to economic importance, hunting methods, religious significance, and in some cases, actual animal densities. For our purposes, these symbols reveal the probable historic distribution of bighorn sheep in the Pelonçillo Mountains.

Documented reports of bighorn are not particularly common. In 1906, Mr. H. H. Hotchkiss told Vernon Bailey that a few bighorn inhabited the extreme southern portion of the Pelonçillo Mountains. In 1907, Mrs. E. L. Fuller, of Lordsburg, reported that a few bighorn occurred in the vicinity of Steeple Rock. However, in 1908, E. A. Goldman and Bailey of the Biological Survey (now the U.S. Fish and Wildlife Service) could not obtain recent records from this area (Bailey 1931). Cahalane (1939) presents evidence that bighorn were present in the Chiricahua Mountains, Arizona about 1900. The Chiricahuas are located 16 km (10 mi.) west of the Pelonçillo Mountains. Cozzens (1967) reported that "an occasional mountain sheep" was seen in Steins Pass, but does not elaborate. During the course of field work, Mr. Bob Evans--a local rancher, reported that in 1970 he had seen a single bighorn ram on Gray Peak. In November 1979, Mr. Johnny Croom of Animas, reported a full curl bighorn ram adjacent to State Road 338 near the cutoff to the XT Ranch, just east of the Pelonçillo Mountains.

Land status and use. Deeded lands comprise approximately 46 percent of the area intensively evaluated as desert bighorn habitat. Public domain administered by the Bureau of Land Management comprises 37 percent; state lands up 10 percent and U.S. Forest Service lands constitute 7 percent (Table 2).

Table 2. Land status in the area intensively evaluated as desert bighorn habitat, Peloncillo Mountains, New Mexico.^a

Ownership	Area			Percent
	Mi ²	Ac	Ha	
Deeded lands	77	49,280	19,943	45
BLM	57	36,740	14,868	33
BLM administered lands	7	4,580	1,853	4
State lands	18	11,760	4,759	11
U.S. Forest Service	12	7,680	3,108	7
Totals	171	109,440	44,289	100

^aSource: BLM land status maps.

Major land use activities include livestock grazing and recreation. Grazing is allowed by the Forest Service and BLM on three and 11 allotments, respectively. The Douglas Ranger District--Coronado National Forest within New Mexico, is divided into eight grazing allotments; however, only three allotments (Deer, Skull, and Juniper Basin) were encompassed in the study area. Fifty-nine percent of this area is

classified by the Forest Service as suitable for livestock grazing.

An average of 5,832 and 4,368 AUM's are allowed by the Forest Service and Bureau of Land Management, respectively, on a continuous yearlong or pasture rotation basis. Data for private lands were not obtained, but in general, these areas are grazed yearlong. According to the Forest Service, more efficient cattle utilization is limited by a lack of developed water sources, and existing sources in need of repairs. Currently, domestic sheep and goats are not grazed on the Peloncillo Mountains.

The history of mining in the Peloncillo Mountains would have to be classed as light, as much of this area escaped the intensive mining activities that were characteristic of many other areas in New Mexico during the late 1800's and early 1900's. Several old mines are found in proximity of Granite Gap and Steeple Rock, and a few operational mines are located in the vicinity of Steins Pass.

Recreational public use of the area is greatest during the fall hunting seasons, and is associated with dove (Zenaida spp.), quail (Callipepla squamata, Lophortyx gambelii), javalina (Dicotyles tajacu) and deer (Odocoileus spp.). Deer harvest data compiled by the Department of Game and Fish indicate an average hunter pressure of 329 for the study area. The average deer harvest is 126 animals, and hunters spend an average of 6.8 days per deer harvested. These data indicate a 38 percent hunter success, compared to the overall state average of 21 percent. This higher hunter success does not

necessarily indicate higher deer densities. A significant proportion of the hunter pressure is from local hunters familiar with the area, thus increasing the hunter success.

Harvest data for javalina show an average hunter pressure of 71, with an average annual harvest of 19. An average of 2.7 days spent per hunter resulted in a 27 percent hunter success. The overall state average hunter success is 25.4. Harvest and hunter pressure data for dove and quail were not obtained.

Bighorn Sheep Reintroduction

Introduction. Desert bighorn have reached a delicate balance between survival and extirpation, and are currently listed as a state endangered species. The Department of Game and Fish has given its highest priority to meeting wildlife needs whenever the viability of a wildlife species is involved. To this end, a bighorn sheep reintroduction program was initiated on the Peloncillo Mountains to insure the continued existence of desert bighorn.

Capture of ewes and transplant. Twelve desert bighorn ewes were captured between November 24-26, 1980 in the Kofa National Wildlife Refuge and the North Plomosa Mountains, Arizona. This was a cooperative effort between the Arizona Department of Game and Fish, U.S. Fish and Wildlife Service, and the New Mexico Department of Game and Fish. Capture was achieved from a helicopter using tranquilizer darts. The sheep were examined, radio-collared, ear tagged, measured and inoculated against contagious ecthyma, blue tongue, and Psoroptic scabies. The sheep were transported in an enclosed trailer and

released on November 27, 1980 into a 16 ha (40 ac.) holding paddock located in the central portion of the Peloncillo Mountains (Table 3) (Figure 2). The sheep were retained in the paddock for seven months. Retaining the animals for this length of time resulted in one generation of lambs being born, and imprinted with the existing habitat. Also, by this time, the lambs were agile and able to keep up with the adult sheep.

Paddock construction. The Department of Game and Fish constructed the temporary holding paddock from 31 m (100 ft.) sections of 2.1 m (7 ft.) high-10 cm (4 in.) nylon mesh nets. The nets were supported by 3 m (10 ft.) steel pipes with a 3.8 cm (1.5 in.) inside diameter, set approximately 8 m (25 ft.) apart. The steel pipes were held upright by 1.2 m (4 ft.), 3.1 cm (1.25 in.) diameter rebar sections, embedded 46 cm (18 in.) into soil or parent material. One 3/8-inch cable section with turnbuckles secured the pipe to the rebar. The steel pipes were anchored to a 91 cm (36 in.) section of 31 cm (1.25 in.) diameter rebar, embedded 46 cm (18 in.) into soil or parent material. A 3/8-inch cable was suspended along the top and bottom of each pipe. The nets were then stretched and secured between the two cables (Figure 8). To prevent lambs from becoming entangled in the net fence, the bottom was lined with .91 m (3 ft.) high poultry wire with a 2.54 cm (1 in.) mesh.

In order to provide an adequate water supply for the bighorn during confinement, and to enhance the possibility of the release site becoming a traditional lambing area, a permanent rain water

Table 3. Data on desert bighorn sheep ewes transplanted on the Peloncillo Mountains, Hidalgo County, New Mexico, November 27, 1980.

Capture Site	Animal ID No.	Age	Radio		SN*
			Frequency	Color	
Kofa NWR	661	4	8.330	White	7834
Kofa NWR	659	1.5	8.420	Orange/white	7835
Kofa NWR	657	6+	9.190	Yellow	7837
Kofa NWR	658	4	9.200	Yellow	7838
Kofa NWR	660	5+	9.330	Orange/yellow	7841
N Plomosa Mtn.	665	7+	8.340	Yellow/white	7836
N Plomosa Mtn.	666	3.5	9.220	Red/yellow	7839
N Plomosa Mtn.	664	3.5	9.310	Red	7840
N Plomosa Mtn.	656	1.5	9.490	Orange	7842
N Plomosa Mtn.	663	1	9.610	White/yellow	7843
N Plomosa Mtn.	672	6+	9.650	Yellow/red	7829
N Plomosa Mtn.	479	6+	9.680	White/red	7832

* radio serial number (SN)

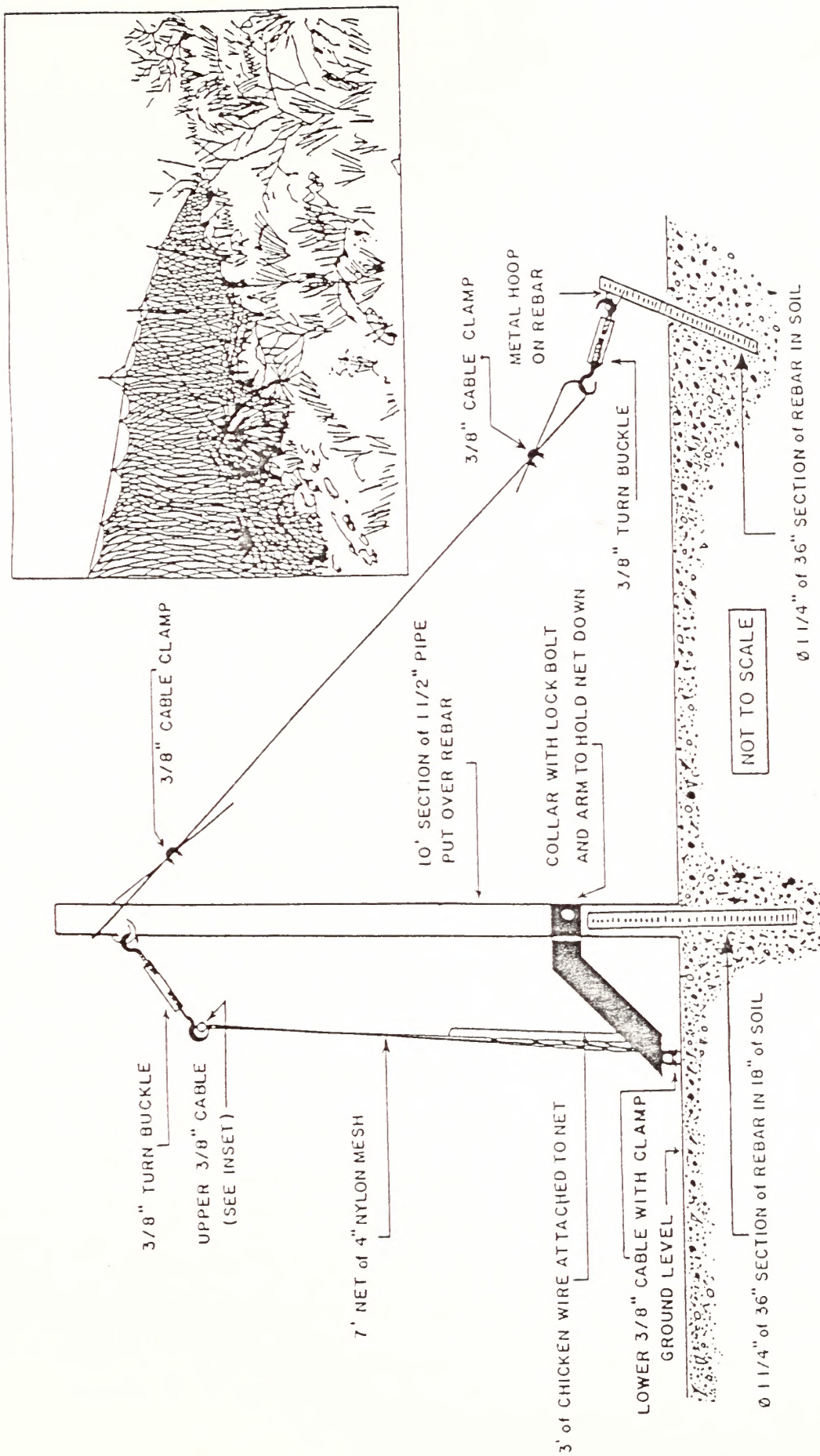


FIGURE 8. DIAGRAM SHOWING CROSS SECTION OF HOLDING PADDOCK

catchment unit was constructed (refer to section on Water Availability).

Predator control. Concurrent with the release of bighorn sheep, an active predator control program was initiated by the Department of Game and Fish. The target species included mountain lions (Felis concolor), coyotes (Canis latrans), and bobcats (Lynx rufus). A total of 11 mountain lions, 32 coyotes, and 11 bobcats was removed during the first 6 months. At the date of this report, February 1982, one documented loss attributed to predation has occurred.

Control of predators to enhance bighorn populations is usually not necessary under normal circumstances. There are, however, certain instances, such as a reintroduction or when remnant populations are involved, when predator control is an important and advisable management tool. Bighorn released into a new area are more vulnerable to predation than animals familiar with escape routes and escape terrain. Existing data on various desert bighorn transplant efforts strongly indicate that large predators, particularly the mountain lion, frequently take advantage of the situation, resulting in serious consequences to the transplanted population and the reintroduction effort (Blaisdell 1972, 1976, Broadbent 1969, Hailey 1964, Kirkpatrick 1976, McCuthchen 1977, 1978, Winkler 1977). Two of six ewes transplanted on the Big Hatchet Mountains were killed by mountain lions within one month of their release (Bavin 1981). Between January and March 1981, mountain lions killed 27 percent of the radio-collared bighorn population ($n = 25$) in the San Andres Mountains (Muñoz in press).

Ewe mortality. Two ewes were lost during confinement. Ewe 656 sustained permanent neck damage when she became entangled in the fence netting. She was captured, treated and transported to the Department's Red Rock Wildlife Experimental area where she died a month later. Ewe 665 died inside the paddock on January 11, 1981. A necropsy revealed extensive subcutaneous hemorrhaging, bruising on the left side of the flank and lumbar region, a 10 cm (4 in.) tear through the peritoneum and peritonitis under the bruised area. Probable cause of death was due to this injury which may have resulted from a fall; however, the peritonitis and shock that resulted from the injury probably contributed to her death (Hopson 1981).

Lamb production. A total of 8 lambs (5 females and 3 males) was born to the 10 surviving ewes. Five lambs were born between January 18-27, and 3 between March 4-8, 1981. The synchrony of lambing was unusual for desert bighorn. As an adaptive strategy, desert bighorn exhibit an extended lambing season encompassing up to 6 months. An extended lambing season would increase the probability that late gestation and early lactation would coincide with a period of adequate precipitation and forage availability (Leslie and Douglas 1979, Sandoval 1979b).

Ram transplant. Ten bighorn rams from Red Rock were released on May 7, 1981, to supplement the 10 ewes and 8 lambs. The rams adapted well to the paddock, as they made no attempts at the fence netting. They remained spatially and sexually segregated from the ewe-lamb segment of the population. The rams occupied the relatively open west slope of the paddock, while the ewes and lambs preferred

the brushy, more rugged east slope. The rams were occasionally seen early in the morning watering and feeding on supplemental feed with the ewes and lambs.

Release from the paddock. On June 26, 1981, approximately 244 m (800 ft.) of fence netting was removed along the upper perimeter of the paddock. Early next morning, 8 ewes and 6 lambs gradually drifted through the opening, leaving 2 ewes, 2 lambs, and 10 rams inside the paddock. Five sheep (3 ewes and 2 lambs) returned that evening and bedded inside the paddock. On the 29th, the remaining ewes and lambs, accompanied by 2 rams left the paddock. This sporadic dispersal resulted in the sheep fragmenting into 3 groups, excluding the rams still inside the paddock. On the morning of the 30th, the ram group left the paddock. The rams remained as a group, ranging within 3.2 km (2 mi.) south of the release site, until July 22 when a low flying helicopter fragmented the group. The rams never regrouped following this episode.

Ram die-off. All 10 rams died during August 1981. Clinical symptoms were first observed on July 22. After the first ram died on August 1, clinical symptoms became more evident; i.e., sporadic and long spasms of coughing, nasal and oral discharges, poor to emaciated body condition, and depressed behavior (Elenowitz 1981a). One ram was collected to obtain fresh tissue samples. One ram died while being treated with terramycin injectable solution. One ewe lamb was found dead; 2 were presumed dead, and 4 of the 5 remaining lambs exhibited signs of illness.

Clinical symptoms and laboratory results indicated chronic bronchial pneumonia as the cause of death with Corynebacterium pyogenes, Pasteurella multocida, Neisseria sp., and Coccidioides immitis as the causative pathogens. Possible predisposing factors included 1) a yet to be identified virus, 2) adverse weather conditions, 3) stress due to adapting to a new environment, compounded by being raised in captivity, and 4) no apparent previous exposure to bronchial pneumonia, consequently no resistance to the disease.

Abnormal pneumonic conditions appear to be widespread in desert bighorn from Arizona. Russo (1956) reported that without exception, adhesions of the lungs to the pleura were found in all sheep collected (n = 12) from western Arizona. He further stated that in all specimens it was impossible to remove the lungs without tearing or cutting the adhesions. Monson (1955) reported that during waterhole counts in the Kofa Mountains, Arizona, "a good many of the Bighorns coughed a great deal. The cough seemed to be associated to some extent with age, as the worst coughers were the old animals." Monson elaborated further: "a lamb with a severe cough and some nasal discharge was seen at High Tank 8, on June 29" [1955]. "It was in noticeably poorer condition, with ribs showing prominently. Despite this, it was at times quite lively, capering alongside its mother. A ram with a profuse nasal discharge, frothy and white, was seen at Burnt Wagon Tank on July 8," [1955]. The ewe that died in the Peloncillo paddock during January 1981 revealed old pleural adhesions and fibrin scattered over the lungs (Hopson 1981). The information

presented here suggests that the ewes and lambs (through passage in utero) had a certain amount of resistance or immunity due to long term exposure to bronchial pneumonia. The rams born in captivity at Red Rock, with no previous exposure to pneumonia, were extremely susceptible.

Necropsies were performed on all but one ram, and tissue samples was collected from most. All the carcasses examined showed the following gross pathological signs to varying degrees:

- 1) Adhesions of pleura from lungs to thoracic wall and diaphragm
- 2) Consolidation of apical, cardiac, and ventral portions of diaphragmatic lobes
- 3) Fibrin and pus deposits (some as large as 30 cm).

Treatment. Treatment was attempted with bait stations consisting of horse pellets and mineral supplement containing neo-terramycin powder concentrate. During confinement to the paddock, sheep consumed over 900 kg (2,000 lbs.) of horse pellets consisting of alfalfa, corn, and molasses. Although above-average precipitation following the release from the paddock resulted in an abundance of high quality, palatable forage, some utilization was documented at one of the treatment stations (Elenowitz 1981b).

CHAPTER III

ALAMO HUECO MOUNTAINS

Description of Study Area

Location. The Alamo Hueco Mountains are located in Hidalgo County, New Mexico, approximately 112 km (70 mi.) southeast of Lordsburg in the extreme southwest corner of the state ($108^{\circ} 27' - 109^{\circ} 14' W \times 31^{\circ} 20' - 31^{\circ} 29' N$). The mountains are situated 8 km (5 mi.) south of the Big Hatchets, and extend to the border of the Republic of Mexico (Figure 9).

The Alamo Hueco Mountains rise some 500 m (1,640 ft.) above the surrounding desert to a maximum elevation of 1,956 m (6,416 ft.) at Emory Peak. The topography along the northwest, north, and northeast flanks is characterized by numerous outcrops of bedrock forming vertical cliffs (Figure 10). In general, the southside of the mountain consists of undulating topography, bisected by numerous drainages (Figure 11). Emory, Cottonwood, Horse and Wood Canyons drain the mountain to the north, east, south and west, respectively.

Climate. The Alamo Hueco Mountains have an arid, continental climate, characterized by sparse and unpredictable precipitation, large diurnal and annual temperature changes, plentiful sunshine, and low humidity.

Precise weather data for the area are lacking. The most representative weather recording station is a Hachita (elevation 1,478 m-4,849 ft.) located 32 km (20 mi.) north of the Alamo Hueco

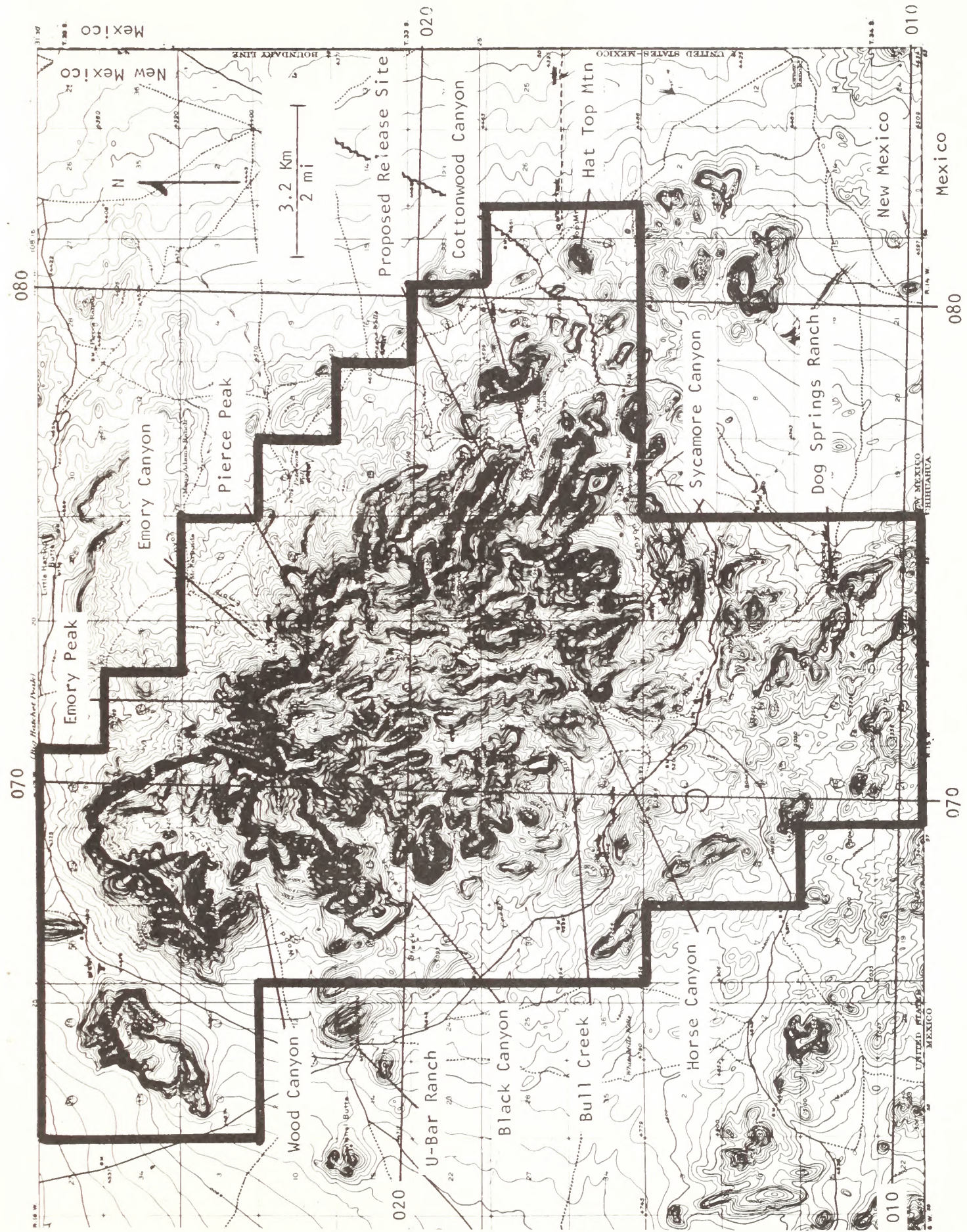


Figure 9. Map of the study area in the Alamo Hueco Mountains, New Mexico showing place names, and the 10,000 meter Universal Transverse



Figure 10. The topography along the northwest, north, and northeast flanks of the Alamo Hueco Mountains is characterized by numerous outcrops of bedrock forming vertical cliffs.



Figure 11. The southside of the Alamo Hueco Mountains (background) consists of undulating topography, bisected by numerous drainages.

Mountains. The mean annual precipitation for Hachita is 24.4 cm (9.6 in.). Fifty-seven percent of the annual precipitation falls between July and September as brief afternoon and evening thunder-showers. July receives the greatest amount with a mean of 5.5 cm (2.16 in.). April receives the least with a mean of .30 cm (.12 in.). The mean annual temperature for Hachita is 59.1° F (15.2° C). December is the coldest month with a mean temperature of 41.3° F (5.2° C). July is the warmest month with a mean maximum temperature of 78.3° F (25.9° C) (Figure 12). The average annual potential evapotranspiration based on Thornthwaites Formula is 80.3 cm/yr. (31.6 in./yr.). The average frost-free season for Hachita is 215 days (Houghton 1972).

Geology. The Alamo Hueco Mountains are in the Mexican Highland section of the Basin and Range province (Feeneman 1931). They are a structurally complex group of Tertiary volcanics oriented in a northwest-southeast direction, with a few outlying areas of Lower Cretaceous limestone and sandstone. The areas of internal drainage surrounding the mountains are filled by Quaternary alluvium (Kottlowski 1960).

Soils. Soils of the Alamo Hueco Mountains include the Rock Land-Haplargids association. These soils are developing in material of igneous origin; however, limestone and other types of sedimentary rocks have contributed varying amounts to the parent materials.

Rock Land, a miscellaneous land type, is a complex of very shallow soils and rock outcrops. The bedrock usually occurs as

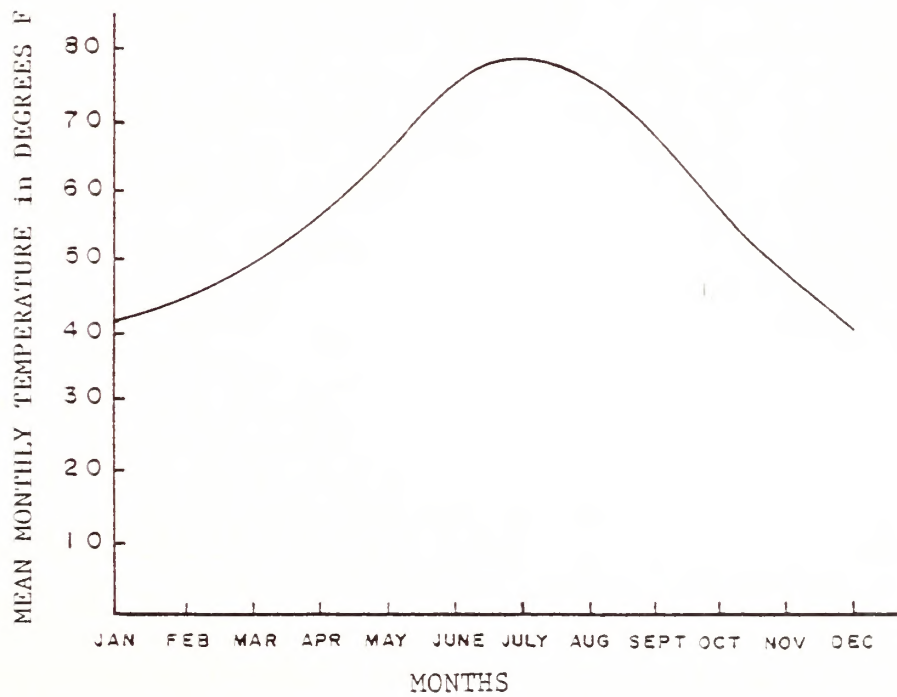
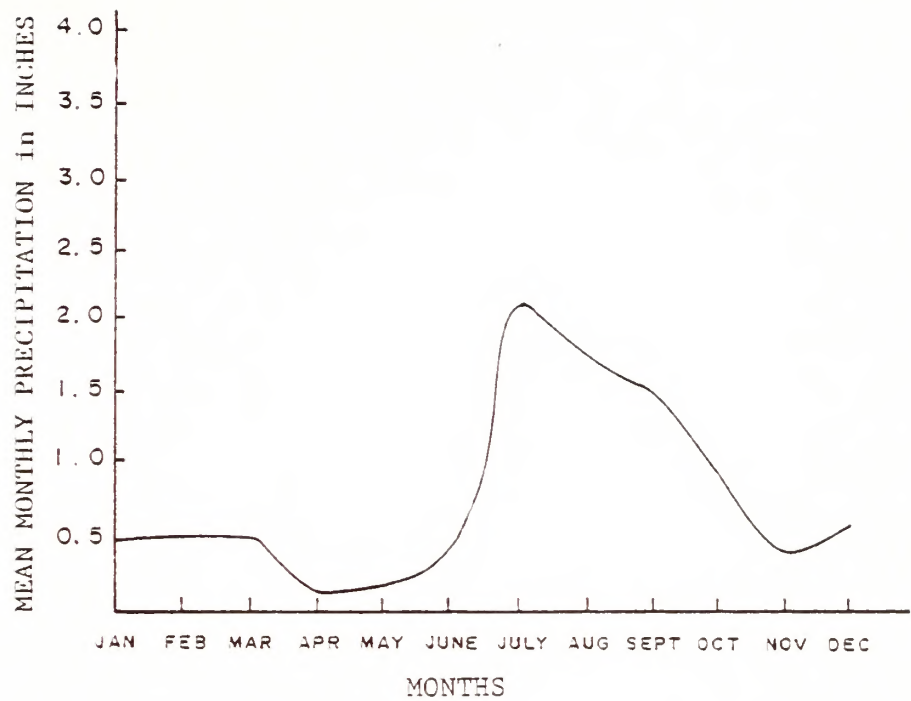


Figure 12. Mean monthly precipitation and temperatures for Hachita, New Mexico, 1966-1976.

vertical or nearly vertical exposures. A thin mantle of cobbly or stony soil commonly occurs between the outcrops of bedrock.

The Haplargids commonly occur on moderately steep landscapes. These soils usually have thin, moderately coarse and medium-textured surface layers over moderately well-developed subsoils. Gravel, cobble, and stones frequently occur in both surface and subsurface layers (Maker et al. 1974).

Flora. The Lower Sonoran Life Zone typifies much of the mountain range. An extensive homogenous grassland type characterizes the majority of the mountain range (Figure 13). Associated species are mostly desert shrubs; however, a mixed shrub/grass type is found within canyon bottoms, on adjacent protected slopes, and below cliffs (Figure 14). Plants identified from the Alamo Hueco Mountains are listed in Appendix D.

The grassland community consists of grama, muhly (Muhlenbergia spp.), dropseed, three awn, wolf-tail (Lycurus phleoides) and silver blue-stem (Andropogon saccharoides). The overstory consists mainly of snakeweed, sacahuista, turpentine bush (Aplopappus laricifolius), and scattered Acacia spp. The mixed shrub/grass community is characterized by oak, skunk bush sumac, spice-bush, and mormon tea (Ephedra spp.), with an understory of grama, three awn, squirrel tail (Sitanion hystrix) and dropseed.

Fauna. The fauna of the Alamo Hueco Mountains is distinctly Chihuahuan in nature (Findley et al. 1975), but lacks species diversity (Hayward et al. 1979). Mountain masses do not occur south of the



Figure 13. A relatively homogenous grassland community near the head of Emory Canyon, Alamo Hueco Mountains.



Figure 14. A mixed shrub/grass type is found within canyon bottoms, on adjacent protected slopes, and below cliffs - Cottonwood Canyon, Alamo Hueco Mountains.

Alamo Huecos; consequently, mammal species are grassland forms rather than woodland types unique to the Peloncillo Mountains. For a detailed inventory of the biota of the Alamo Huecos, the reader is referred to Hayward et al. (1979).

Peripheral or vagrant species reported by Hayward et al. (1979) include thick-billed kingbirds (Tyrannus crassirostris), painted buntings (Passerina ciris), and Yarrow's spiny lizard (Sceloporus jarrovi). The latter was new to the area and represented a range extension.

Mammals most frequently encountered during the course of field work included mule deer, javalina, coyotes, and rabbits. Three mountain lions, (a female and two cubs) were observed at the head of Peterson Canyon.

Water availability. Twenty-four water sources were located within and adjacent to the Alamo Hueco Mountains (Table 20). The majority of these are limited to manmade sources. Permanent flowing springs are located in Emory, Horse and Cottonwood Canyons. Water is also available at Dog Springs located in the extreme southern portion of the mountain range.

Windmills and stock tanks provide a reliable source of water; however, due to recent management changes at the U-Bar Ranch, numerous windmills have been shut down and in one instance (Sycamore Well), dismantled.

History of bighorn occupancy. Edgar Alexander Mearns, physician and naturalist of the Mexican Boundary Survey, made extensive collections of mammals along the southern border of New Mexico in 1892 and 1893. Mearns party collected a large bighorn ram on September 11, 1893, within 457 m (500 yds.) of Dog Springs. Mearns also reported finding numerous

horns and sign of mountain sheep in the rugged canyons of the Alamo Hueco Mountains, suggesting that bighorn were rather common. Gordon (1956) wrote that Mr. Van Ormen, foreman and occupant of Dog Springs Ranch for several years, saw 4 and 8 sheep on two occasions in the Alamo Huecos. Ramon Pavella, a former long-term resident of this area, reported that in 1898, while herding domestic sheep (Ovis aries) with his father in Sycamore Canyon on the southeast side of the mountain range, a large bighorn ram came up and joined their flock of domestic sheep. The ram proved so troublesome that he had to be driven away. Mr. Bill McKinney related observing bighorn in the Emory Canyon-Pierce Peak area about 1915. Lewis Lynch saw 3 ewes and 1 ram in this same area in the spring of 1941. In September 1960, Huey Patterson observed 9 bighorn in Little Hat Top (Gross 1960). In 1972, Lanny Wilson (former BLM State Wildlife Biologist) followed a ewe and lamb from Sheridan Canyon in the Big Hatchets, to the Alamo Hueco Mountains. In January 1977, 6 bighorn crossed from the Big Hatchets to the Alamo Hueco Mountains at Peterson Canyon. The sheep were observed several times at the head of Peterson Canyon where it boxes up on the rim of the Alamo Huecos (Shorty Lyons, former NMGF employee, personal communication, September 10, 1978). Mr. Lyons also stated that a few years ago, Tom Day, a U-Bar ranch employee, roped a big ram in the Alamo Huecos, then released it. Mr. Tim Read, Recreation Specialist-BLM, reported 7 bighorn sheep on June 10, 1981, in the Gillespie Mountains located 24 km (15 mi.) west of the Alamo Huecos. In 1977, 9 bighorn sheep were reported near Culverson, approximately 20 km (12 mi.) west of the Alamo Hueco Mountains (Lenarz 1978). Bighorn sheep observations in the Alamo Hueco Mountains are summarized in Table 4.

Table 4. Desert bighorn sheep observed in the Alamo Hueco Mountains, New Mexico, and vicinity, 1893-1981.

Date	Observer	Composition	Location
1892	Dr. E. A. Mearns	collected 1 mature ram	Dog Springs
1898	Ramon Pavella	1 mature ram	Sycamore Canyon
1900	Van Ormen	4 unclassified	Alamo Hueco Mountains
1900	Van Ormen	8 unclassified	Alamo Hueco Mountains
1915	Bill McKinney	-	Emory Canyon
1941	Lewis Lynch	3 ewes, 1 ram	Emory Canyon
1960	Huey Patterson	6 ewes, 2 lambs, 1 ram	Little Hat Top
1970	Tom Day	roped 1 mature ram	Alamo Hueco Mountains
1972	Lanny Wilson	1 ewe, 1 lamb	Alamo Hueco Mountains
1977	Shorty Lyons	6 unclassified	Peterson Canyon
1977	Mark Lenarz ^a	9 unclassified	Culverson
1981	Tim Read	7 unclassified	Gillespie Mountains

^aReported by Lenarz (1978).

Land status and use. Approximately 54 percent of the area evaluated as desert bighorn habitat is administered as public lands by the BLM. Pacific Western Land Company, a subsidiary of Phelps-Dodge Corporation, owns about 43 percent, which is known as the U-Bar Ranch. Three percent of the area is state owned (Table 5).

Table 5. Land status in the Alamo Hueco Mountains, New Mexico.^a

Ownership	Area			
	Mi ²	Ac	Ha	Percent
BLM	44	28,160	11,396	54
Pacific Western	35	22,400	9,065	43
State Lands	2	1,280	518	3
Totals	81	51,840	20,979	100

^aSource: BLM land status maps.

Pacific Western has restricted all public access into the Alamo Hueco Mountains. The major land use is livestock grazing. Approximately 2,600 AUM's are allowed by permit. However, the mountain range has not been intensively grazed for 5 years. Localized areas currently being grazed include Horse, Cottonwood, Peterson, Jansen, Emory, Wood, Sycamore, and Bull Canyons (Homer Bryant, U-Bar Ranch, personal communication, November 12, 1980).

CHAPTER IV

HABITAT AVAILABILITY

Peloncillo Mountains

Elevation. The mean elevation of the study area in the Peloncillo Mountains is 1,622 m (5,322 ft.) with a range of 1,512-2,112 m (4,961-6,928 ft.). Sixty-two percent of the potential bighorn habitat is between 1,372-1,676 m (4,500-5,000 ft.), and 29 percent is found above 1,676 m (5,500 ft.) (Table 6).

Exposure. Areas of relatively homogenous topography characterized by <5 percent slope such as desert flats, valley bottoms, and ridge-lines were computed as flat. These areas accounted for 49 percent of the habitat in the Peloncillo Mountains. East, northeast, and southeast exposures comprised 24 percent of the habitat. West, southwest, and northwest exposures made up 15 percent, and north and south exposures accounted for 6 percent each (Table 7).

Slope. The corresponding values of gradient in Table 8 were defined as vertical change in distance divided by horizontal change, expressed as percent slope. Areas characterized by <5 percent slope such as piedmonts, desert flats, and ridge-lines were computed as flat and accounted for 49 percent of the available habitat. Slope gradients between 10 and 20 percent comprised 21 percent of the habitat. Seventeen percent of the habitat had slopes between 5 and 10 percent. Only 3.5 percent of the habitat was characterized by slopes >30 percent (Table 8).

Table 6. Availability of elevations in the Peloncillo Mountains, New Mexico.

Habitat Type	Elevation in Meters (feet)					Mean Elevation
	1219-1372 (4000-4500)	1372-1524 (4500-5000)	1524-1676 (5000-5500)	1676-1829 (5500-6000)	1829-1981 (6000-6500)	1981-2134 (6500-7000)
Grass/desert shrub	437	2,199	1,474	622	157	8
Mixed shrub	0	408	1,980	870	51	0
Desert shrub	402	340	228	409	107	0
Grassland	0	0	210	1,005	147	0
Pinon-Juniper	0	13	463	15	70	209
Live oak	3	25	73	84	75	22
Mountain shrub	0	0	0	0	0	5
Totals	842	2,985	4,428	3,005	607	244
Percent	6.9	24.6	36.6	24.8	5.0	2.0
$\bar{X}$	-	-	-	-	-	-
						1,622(5,322)

Numbers in table represent computerized counts of grids (plots) encompassing 3.6 ha (9 ac.) each.

Table 7. Availability of exposures in the Peloncillo Mountains, New Mexico.

Habitat Type	Flat	Exposure								Total
		N	NE	E	SE	S	SW	W	NW	
Grass/desert shrub	2,762	298	397	372	280	191	179	190	228	4,897
Mixed shrub	1,725	161	274	308	363	209	95	65	109	3,309
Desert shrub	450	100	69	62	89	134	183	231	174	1,492
Grassland	364	96	96	176	174	106	117	116	117	1,362
Piñon-Juniper	619	13	14	36	17	8	17	27	21	772
Live oak	61	31	65	22	19	25	26	11	22	282
Mountain shrub	0	0	0	0	2	1	1	1	0	5
Totals	5,981	699	915	976	944	674	618	641	671	12,119
Percent	49	6	8	8	8	6	5	5	5	

Numbers in table represent computerized counts of grids (plots) encompassing 3.6 ha (9 ac.) each.

Table 8. Availability of slope in the Peloncillo Mountains, New Mexico.

Habitat Type	Flat	Percent Slope						Total
		5-10	10-20	20-30	30-40	40-50	50-60	
Grass/desert shrub	2,762	785	765	372	180	26	7	4,897
Mixed shrub	1,725	635	681	220	46	2	0	3,309
Desert shrub	450	249	442	260	58	7	2	1,468
Grassland	364	284	492	162	54	6	0	1,362
Piñon-Juniper	619	64	50	18	7	5	0	763
Live oak	61	44	98	53	21	3	2	282
Mountain shrub	0	0	0	0	1	1	3	5
Totals	5,981	2,061	2,528	1,085	367	50	14	12,086
Percent	49.5	17.0	21.0	8.9	3.0	.4	.1	

Numbers in table represent computerized counts of grids (plots) encompassing 3.6 ha (9 ac.) each.

Vegetation. Seven habitat vegetation types were identified in the Peloncillo Mountains. These include grass/desert shrub, mixed shrub, desert shrub, grassland, piñon-juniper, live-oak, and mountain shrub. The grass/desert shrub type comprised 40 percent. The mixed shrub type made up 27.0 percent, followed by the desert shrub and grassland types with 12 and 11 percent, respectively (Table 9).

Vegetation analysis indicated an overall ground cover of 43 percent. Grasses and shrubs had a density of 20 and 19 percent, respectively. Forbs accounted for 3 percent of the cover. The relative botanical composition was 46 percent grasses, 45 percent shrubs, and 8 percent forbs (Table 10) (Appendix C).

Forage production and animal abundance. Total herbaceous forage production in the Peloncillo Mountains was 252 kg/.4 ha (555 lbs./ac.). Forage production ranged from 11 kg/.4 ha (25 lbs./ac.) in the desert shrub and piñon-juniper communities, to 113 kg/ha (250 lbs./ac.) in the grassland community. Pellet group transects indicated an average of 298 cattle, 181 deer, 89 rabbit, and 7 horse fecal groups per acre (2.471 ha), respectively (Table 11).

Water. Forty-two water sources were evaluated in the Peloncillo Mountains in terms of availability, topography, and vegetative communities. Sixty-nine percent of these water sources consist of earth or concrete stock tanks that hold water only during the summer rainy season. Metal stock tanks and windmills provide a reliable source of free water, and comprised 14 and 12 percent of the available waters, respectively. Springs and rain catchment units made up only 5 percent each of the available sources (Table 12).

Table 9. Relative size and mean elevation in meters (feet) of habitat types in the Peloncillo Mountains, New Mexico.

Habitat Type	Availability				Percent	Mean Elevation
	km ²	Mi ²	Ha	Ac		
Grass/desert shrub	179	69	17,863	44,141	40.0	1512 (4961)
Mixed shrub	119	46	11,950	29,530	27.0	1626 (5335)
Desert shrub	55	21	5,550	13,714	12.0	1547 (5075)
Grassland	51	19	5,081	12,555	11.0	1600 (5250)
Piñon-Juniper	29	11	2,888	7,135	7.0	1745 (5727)
Live oak	10	4	1,049	2,592	3.0	1603 (5259)
Mountain shrub	-	-	22	54	.0	1722 (5649)
Totals	443	171	44,289	109,440	100.0	
$\bar{X}$	-	-	-	-	-	1622 (5322)

Table 10. Vegetative cover and composition in the Peloncillo Mountains, New Mexico.

Forage Class - Species ^a	Percent Ground Cover	Percent Ground Composition
GRASSES: Relative composition - 46.1%		
<u>Bouteloua curtipendula</u>	3.69	18.64
<u>Bouteloua eriopoda</u>	2.79	14.12
<u>Bouteloua gracilis</u>	2.46	12.42
<u>Sporobolus</u> spp.	1.45	7.34
<u>Koeleria cristata</u>	1.45	7.34
Others	7.89	40.14
Total	19.73	100.00
SHRUBS: Relative composition - 45.6%		
<u>Acacia constricta</u>	1.84	9.40
<u>Xanthocephalum sarothrae</u>	1.82	9.30
<u>Dasyllirion wheeleri</u>	1.80	9.20
<u>Aloysia wrightii</u>	1.80	9.20
<u>Nolina microcarpa</u>	1.73	8.84
Others	10.57	54.06
Total	19.56	100.00
FORBS: Relative composition - 8.3%		
<u>Croton</u> spp.	1.00	28.10
<u>Thelesperma longipes</u>	.67	18.75
<u>Melampodium leucanthum</u>	.44	12.50
<u>Eriogonum</u> spp.	.44	12.50
<u>Artemisia ludoviciana</u>	.44	12.50
Others	.55	15.65
Total	3.54	100.00
Total vegetative cover	42.83	
Rock and erosion pavement	47.21	
Bare ground	9.96	
Grand Total	100.00	

^aCommon names are found in Appendix A.

Table 11. Forage production and animal abundance relative to habitat types, Peloncillo Mountains, New Mexico.

	Grass/Desert Shrub	Habitat Type						Totals
		Desert Shrub	Mixed Shrub	Desert Shrub	Grassland	Piñon-Juniper	Live Oak	
Size in hectares (ac.)	17,863(44,141)	11,950(29,530)	5,550(13,714)	5,081(12,555)	2,888(7,135)	1,049(2,592)	22(54)	44,402(109,721)
Mean elevation in meters (ft.)	1,512(4,961)	1,626(5,335)	1,547(5,075)	1,600(5,250)	1,745(5,727)	1,603(5,259)	1,722(5,649)	-
Forage production Kg./ha.	84	34	28	140	11	22	17	336
Fecal group pellets No./ha.:								
cattle	294	34	57	282	10	7	52	736
horses	7	0	0	10	0	0	0	17
deer	27	64	47	15	84	106	104	447
rabbits	84	22	30	32	17	15	20	220

Table 12. (continued).

Numerical Designation ^a	Type	Grid Coordinates		Water Availability ^b											
		N-S	E-W	J	F	M	A	M	J	J	A	S	O	N	D
22	metal tank	64.8	94.0	1	1	1	1	1	0	0	0	0	0	1	1
23	stock tank ^c	66.0	13.6	0	0	0	0	0	0	1	1	1	1	0	0
24	stock tank	66.0	13.8	0	0	0	0	0	0	1	1	1	1	0	0
25	stock tank	65.8	17.4	0	0	0	0	0	0	1	1	1	1	0	0
26	stock tank	65.0	17.0	0	0	0	0	0	0	1	1	1	1	0	0
27	stock tank	64.2	12.9	1	1	0	0	0	0	1	1	1	1	1	1
28	windmill	61.2	10.6	0	0	0	0	0	0	1	1	1	1	0	0
29	stock tank	58.2	8.2	0	0	0	0	0	0	1	1	1	1	0	0
30	stock tank	57.8	10.2	0	0	0	0	0	0	1	1	1	1	0	0
31	stock tank	57.2	11.6	0	0	0	0	0	0	1	1	1	1	0	0
32	spring	56.2	8.2	0	0	0	0	0	0	1	1	1	1	0	0
33	stock tank	55.4	9.4	0	0	0	0	0	0	1	1	1	1	0	0
34	metal tank	55.0	11.2	0	0	0	0	0	0	1	1	1	1	0	0
35	stock tank	52.6	10.2	1	1	0	0	0	0	1	1	1	1	1	1
36	stock tank	52.0	11.0	0	0	0	0	0	0	1	1	1	1	0	0
37	stock tank	45.0	8.8	0	0	0	0	0	0	1	1	1	1	0	0
38	stock tank	44.4	11.6	0	0	0	0	0	0	1	1	1	1	0	0
39	stock tank	43.2	12.2	0	0	0	0	0	0	1	1	1	1	0	0
40	stock tank	41.6	9.8	0	0	0	0	0	0	1	1	1	1	0	0
41	stock tank	41.4	11.2	0	0	0	0	0	0	1	1	1	1	0	0
42	metal tank	56.5	10.5	1	1	1	1	0	0	0	0	0	0	1	1

^aNames were not available for all water sources.^b1 = water present during that month, 0 = no water present during that month.^cConcrete or earth tanks.

Water sources are situated between 1,349-1,938 m (4,427-6,356 ft.), at a mean elevation of 1,585 m (5,200 ft.). The mean slope for these water sources is 17 percent. Fifty-one percent are found on northeast, east, and southeast exposures, and 23 percent occur on south, southwest, and northwest exposure. Twenty-six percent are found on north and south exposures (Table 13).

Distribution of water relative to vegetative types indicated that the majority are located in the grass/desert shrub community (45 percent), followed by the piñon-juniper (28 percent), and desert shrub (9 percent) communities (Table 13).

Table 13. Water availability relative to physiographic characteristics in the Peloncillo Mountains, New Mexico.

Numerical	Designation	Type	Elevation in Meters (feet)	Slope (percent)	Exposure	Vegetation	Type
1	stock tank	stock tank	1,391 (4,565)	7	East	Mixed shrub	
2	windmill	windmill	1,431 (4,695)	11	North ^b	Grass/desert shrub	
3	stock tank	stock tank	1,366 (4,481)	0 ^a	0	Grass/desert shrub	
4	windmill	windmill	1,349 (4,427)	0	0	Grassland	
5	stock tank	stock tank	1,372 (4,502)	0	0	Grass/desert shrub	
6	windmill	windmill	1,371 (4,498)	0	0	Grass/desert shrub	
7	metal tank	metal tank	1,381 (4,530)	0	0	Grass/desert shrub	
8	stock tank	stock tank	1,436 (4,713)	13	East	Grass/desert shrub	
9	stock tank	stock tank	1,379 (4,523)	0	0	Grass/desert shrub	
10	metal tank	metal tank	1,400 (4,594)	0	0	Grass/desert shrub	
11	stock tank	stock tank	1,573 (5,162)	35	Northeast	Grass/desert shrub	
12	water catchment	water catchment	1,668 (5,473)	0	0	Grass/desert shrub	
13	stock tank	stock tank	1,579 (5,181)	22	Northeast	Grass/desert shrub	
14	metal tank	metal tank	1,477 (4,846)	26	South	Desert shrub	
15	stock tank	stock tank	1,394 (4,575)	0	0	Live oak	
16	stock tank	stock tank	1,632 (5,354)	19	Northeast	Grass/desert shrub	
17	stock tank	stock tank	1,579 (5,180)	7	Northeast	Mixed shrub	
18	stock tank	stock tank	1,566 (5,139)	12	South	Grass/desert shrub	
19	stock tank	stock tank	1,772 (5,813)	39	North	Grass/desert shrub	
20	stock tank	stock tank	1,411 (4,631)	9	Northwest	Desert shrub	
21	windmill	windmill	1,434 (4,705)	16	West	Desert shrub	

Table 13. (continued).

Numerical Designation	Type	Elevation in Meters (feet)	Slope (percent)	Exposure	Vegetation Type
22	metal tank	1,498(4,916)	19	West	Desert shrub
23	stock tank	1,931(6,334)	34	South	Mixed shrub
24	stock tank	1,938(6,356)	32	South	Juniper
25	stock tank	1,552(5,091)	15	North	Grass/desert shrub
26	stock tank	1,548(5,079)	11	Southeast	Grass/desert shrub
27	stock tank	1,761(5,777)	7	West	Juniper
28	windmill	1,661(5,451)	10	Southeast	Juniper
29	stock tank	1,669(5,541)	8	East	Live oak
30	stock tank	1,634(5,360)	6	Northeast	Juniper
31	stock tank	1,606(5,270)	14	East	Juniper
32	spring	1,612(5,290)	29	Southwest	Live oak
33	stock tank	1,704(5,591)	0	0	Juniper
34	metal tank	1,664(5,460)	12	North	Juniper
35	stock tank	1,801(5,909)	21	East	Grass/desert shrub
36	stock tank	1,748(5,736)	15	East	Grass/desert shrub
37	stock tank	1,821(5,974)	0	0	Piñon-Juniper
38	stock tank	1,724(5,655)	10	Southwest	Piñon-Juniper
39	stock tank	1,671(5,481)	10	East	Juniper
40	stock tank	1,749(5,738)	10	Southeast	Piñon-Juniper
41	stock tank	1,648(5,408)	0	0	Piñon-Juniper
42	metal tank	1,664(5,456)	12	Southwest	Grass/desert shrub

^a Areas with <5 percent slope were classified as flat.^b Exposure was not calculated for areas <5 percent slope.

Alamo Hueco Mountains

Elevation. The mean elevation of the Alamo Hueco Mountains is 1,573 m (5,162 ft.), with a range of 1,219 -1,956 m (4,000-6,416 ft.). Eighty-one percent of the mountain range lies between 1,372 -1,676 m (4,500-5,500 ft.), and 16 percent is between 1,676 1,829 m (5,500-6,000 ft.). Two percent of the mountain ranges lies above 1,829 m (6,000 ft.), and 1 percent is below 1,372 m (4,500 ft.) (Table 14).

Exposure. Areas characterized by <5 percent slope accounted for 45 percent of the available exposures. Northeast, east, and southeast exposures comprised 23 percent of the habitat, and southwest, west and northwest exposures made up 22 percent. North and south exposures accounted for only 4 and 5 percent of the habitat, respectively (Table 15).

Exposure availability is reflected by the geographic orientation of the Alamo Hueco Mountains. The mountain range is structurally circular in outline, with a series of vertical or nearly vertical rock outcrops around the periphery. The summit is characterized by relatively gentle, undulating topography (Figures 10 and 11).

Slope. Percent slope was defined as vertical change in distance divided by horizontal change. Areas characterized by <5 percent slope such as desert flats, valley bottoms, and ridge-lines were computed as flat and accounted for 45 percent of the available habitat. Slope gradients between 5-20 percent comprised 37 percent of the habitat. Fifteen percent was characterized by slopes between 20-40 percent. Slopes >40 percent made up 3 percent of the habitat (Table 16).

Table 14. Availability of elevation in the Alamo Hueco Mountains, New Mexico.

Habitat	Elevation in Meters (feet)								Mean Elevation
	1219-1372 (4000-4500)	1312-1524 (4500-5000)	1524-1676 (5000-5500)	1676-1829 (5500-6000)	1829-1981 (6000-6500)	1981-2134 (6500-7000)			
Grassland	0	391	787	502	59	7			1622 (5322)
Desert shrub	0	388	1,058	96	3	0			1572 (5157)
Mountain shrub	0	24	338	315	79	10			1696 (5563)
Half-shrub	0	0	23	0	0	0			1600 (5250)
Creosote	0	117	12	0	0	0			1462 (4797)
Mesquite	1	1,347	235	0	0	0			1470 (4824)
Total	1	2,267	2,453	913	141	17			
Percent	0	39	42	16	2	.3			

Numbers in table represent computerized counts of grids (plots) encompassing 3.6 ha (9 ac.) each

Table 15. Availability of exposures in the Alamo Hueco Mountains, New Mexico.

Habitat	Flat	N	NE	E	Exposure				NW	Total
					SE	S	SW	W		
Grassland	559	90	210	161	132	116	178	141	159	1,746
Desert shrub	782	47	70	83	100	108	129	139	87	1,545
Mountain shrub	31	84	179	112	59	45	50	75	131	766
Half-shrub	5	4	3	3	5	1	0	1	1	23
Creosote	82	0	7	12	11	6	9	2	0	129
Mesquite	1,182	28	83	35	75	51	39	32	58	1,583
Total	2,641	253	552	406	382	327	405	390	436	
Percent	45	4	10	7	6	5	7	7	8	

Numbers in table represent computerized counts of grids (plots) encompassing 3.6 ha (9 ac.) each

Table 16. Availability of slope in the Alamo Hueco Mountains, New Mexico.

Habitat Type	Flat	Percent Slope					Total
		5-10	10-20	20-30	30-40	40-50	
Grassland	559	314	544	223	85	21	1,746
Desert shrub	782	258	336	133	28	8	1,545
Mountain shrub	31	58	203	230	163	68	766
Half-shrub	5	6	7	2	3	0	23
Creosote	82	14	26	6	1	0	129
Mesquite	1,182	259	112	24	6	0	1,583
Total	2,641	909	1,228	618	286	97	13
Percent	45	16	21	10	5	2	1

Numbers in table represent computerized counts of grids (plots) encompassing 3.6 ha (9 ac.) each

Vegetation. Six habitat-vegetation types were identified in the Alamo Hueco Mountains. These include grassland, desert shrub, mountain shrub, half-shrub, creosote and mesquite. The grassland type comprised 30 percent, the desert shrub and mesquite types each constituted 27 percent, and the mountain shrub type made up 13 percent (Table 17).

Vegetation analysis revealed an overall ground cover of 35 percent. Grasses comprised 17 percent, shrubs accounted for 13 percent, and forbs made up 5 percent. The relative botanical composition was 47 percent grasses, 38 percent shrubs, and 15 percent forbs (Table 18) (Appendix E).

Forage production and animal abundance. Total herbaceous forage production in the Alamo Hueco Mountains was 207 kg/.4 ha (455 lbs./ac.). Forage production ranged from 4.5 kg/.4 ha (10 lbs./ac.) in the creosote community to 125 kg/.4 ha (275 lbs./ac.) in the grassland community. Animal abundance data revealed an average of 171 cattle, 89 rabbit, 86 deer, and 6 horse pellet groups/2.471 ha (1 ac.), respectively (Table 19).

Water. Twenty-four water sources were evaluated in the Alamo Hueco Mountains in terms of availability, topography, and vegetative communities. Forty-six percent of these water sources consist of windmills, 33 are earth and/or steel tanks, and 21 percent are springs and seeps. Fifty-eight percent of the sources were identified as providing a year-long water supply (Table 20).

Water sources are located between 1,416-1,763 m (4,647-5,785 ft.), at a mean elevation of 1,581 m (5,186 ft.). The mean slope for these

Table 17. Relative size and mean elevation in meters (feet) of habitat types, Alamo Hueco Mountains, New Mexico.

Habitat Type	Availability				Percent	Mean Elevation
	km ²	mi ²	Ha	Ac		
Grassland	63.4	24.5	6,336	15,657	30	1,622 (5,322)
Desert shrub	55.9	21.6	5,606	13,854	27	1,572 (5,157)
Mountain shrub	27.7	10.7	2,780	6,870	13	1,696 (5,563)
Half-shrub	.83	.32	84	207	.4	1,600 (5,250)
Creosote	4.7	1.9	469	1,158	2	1,462 (4,797)
Mesquite	57.5	22.2	5,745	14,196	27	1,470 (4,824)
Totals	210.3	81.2	21,021	51,942	99.4	-
$\bar{X}$	-	-	-	-	-	1,570 (5,152)

Numbers in table represent computerized counts of grids (plots) encompassing 3.6 ha (9 ac.) each. Computerized counts are more accurate than area determination using a compensating polar planimeter, thus the discrepancy between Tables 13 and 17.

Table 18. Vegetative cover and composition in the Alamo Hueco Mountains, New Mexico.

Forage Class - Species ^a	Percent Ground Cover	Percent Ground Composition
GRASSES: Relative composition - 47.4%		
<u>Bouteloua eriopoda</u>	4.25	24.28
<u>Bouteloua curtipendula</u>	3.00	17.14
<u>Bouteloua hirsuta</u>	2.25	12.85
<u>Lycurus phleoides</u>	1.75	10.00
<u>Muhlenbergia spp.</u>	1.75	10.00
Others	3.75	25.73
Total	16.75	100.00
SHRUBS: Relative composition - 37.7%		
<u>Aplopappus laricifolius</u>	2.73	20.51
<u>Aloysia wrightii</u>	1.75	13.14
<u>Nolina microcarpa</u>	1.35	10.14
<u>Dasyllirion wheeleri</u>	1.08	8.11
<u>Xanthocephalum sarothrae</u>	.88	6.61
Others	5.52	41.49
Total	13.31	100.00
FORBS: Relative composition - 15.25%		
<u>Croton spp.</u>	2.00	38.09
<u>Artemisia ludoviciana</u>	1.50	28.57
<u>Hedyotis spp.</u>	.75	14.28
<u>Eriogonum jamesii</u>	.50	9.25
<u>Sphaeralcea spp.</u>	.25	4.76
Others	5.25	4.76
Total	5.25	99.71
Total vegetative cover	35.31	
Rock and erosion pavement	48.52	
Bare ground	16.17	
Grand Total	100.00	

^aCommon names are found in Appendix D.

Table 19. Forage production and animal abundance relative to habitat types, Alamo llueco Mountains, New Mexico.

	Grassland	Desert Shrub	Habitat Type				Creosote	Mesquite	Totals
			Mountain Shrub	Half-Shrub					
Size in hectares (ac.)	6,336 (15,657)	5,606 (13,854)	2,780 (6,870)	84 (207)			469 (1,158)	5,745 (14,196)	21,021 (51,942)
Mean elevation in meters (ft.)	1,622 (5,322)	1,572 (5,157)	1,696 (5,563)	1,600 (5,250)			1,462 (4,797)	1,470 (4,824)	-
Forage production Kg./ha.	140	28	34	28			6	6	241
Fecal group pellets No./ha.:									
cattle	215	77	47	57			10	17	422
horses	15	0	0	0			0	0	15
deer	22	77	106	7			0	0	212
rabbits	44	54	32	27			17	44	220

Table 20. Water availability in the Alamo Hueco Mountains, New Mexico.

Name	Type	Grid Coordinates		Water Availability ^a											
		N-S	E-W	J	F	M	A	M	J	J	A	S	O	N	D
Upper Sycamore	earth tank	15.0	74.0	0	0	0	0	0	0	1	1	1	0	0	0
Section 32	windmill	16.2	68.6	1	1	1	1	1	1	1	1	1	1	1	1
Stone Cabin	earth tank	17.8	77.8	1	1	1	0	0	0	1	1	1	1	1	1
Horse Canyon	windmill	16.8	72.2	1	1	1	1	1	1	1	1	1	1	1	1
Northwest	earth tank	26.6	66.2	0	0	0	0	0	0	1	1	1	0	0	0
Section 3	windmill	14.2	72.0	1	1	1	1	1	1	1	1	1	1	1	1
Unnamed	earth tank	16.0	69.6	0	0	0	0	0	0	1	1	1	0	0	0
Sycamore	windmill	15.8	76.2	0	0	0	0	0	0	0	0	0	0	0	0
Dry	earth tank	19.0	76.8	0	0	0	0	0	0	1	1	1	0	0	0
Cottonwood	spring	19.2	74.2	1	1	1	1	0	0	1	1	1	1	1	1
Upper Bull	earth tank	19.0	71.0	0	0	0	0	0	0	1	1	1	0	0	0
Upper Horse	earth tank	20.8	72.8	0	0	0	0	0	0	1	1	1	0	0	0
Upper Pierce	seep	22.6	72.8	1	1	1	1	0	0	1	1	1	1	1	1
Lower Pierce	seep	22.0	73.0	1	1	1	1	0	0	1	1	1	1	1	1
McFarlands	windmill	25.0	74.2	1	1	1	1	1	1	1	1	1	1	1	1
Petersons	windmill	22.8	76.2	1	1	1	1	1	1	1	1	1	1	1	1
Jensons	windmill	21.2	78.8	1	1	1	1	1	1	1	1	1	1	1	1
Section 21	windmill	18.8	80.0	1	1	1	1	1	1	1	1	1	1	1	1
Hat Top	steel tank	17.2	81.8	1	1	1	1	1	1	1	1	1	1	1	1
Dog	spring	11.4	74.6	1	1	1	1	1	1	1	1	1	1	1	1
Pierce	windmill	23.2	73.0	1	1	1	1	1	1	1	1	1	1	1	1
Wood	windmill	23.0	67.4	1	1	1	1	1	1	1	1	1	1	1	1
Black	windmill	20.0	67.4	1	1	1	1	1	1	1	1	1	1	1	1
Thicket	spring	19.2	72.8	1	1	1	1	1	1	1	1	1	1	1	1

^a1 = water present during that month, 0 = no water present during that month.

water sources is 16 percent. Thirty-eight percent of the water sources are found on east and southeast exposures, 17 percent on south and southwest exposures, and 18 and 4 percent on northeast and west exposures, respectively (Table 21).

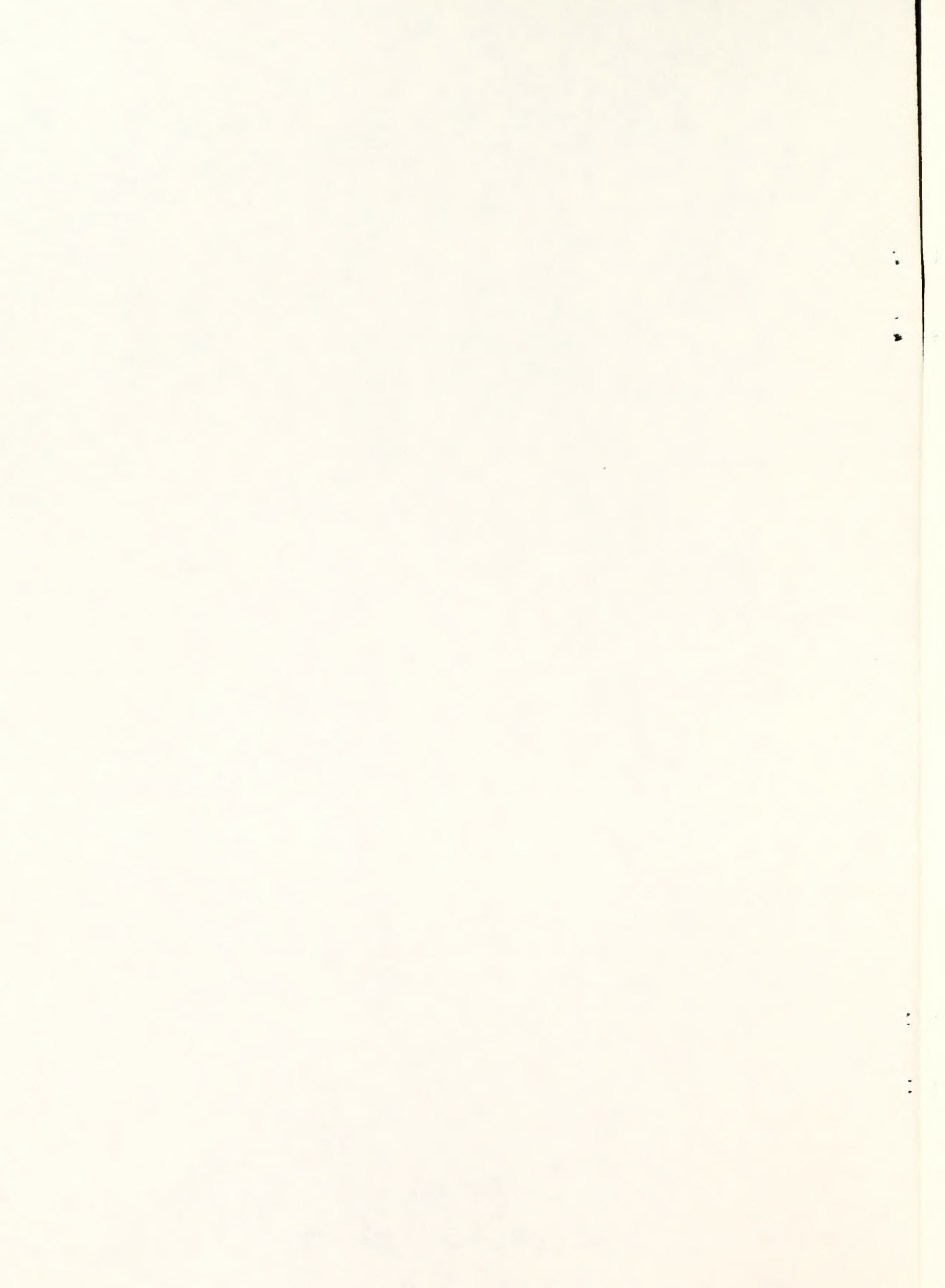
Distribution of water relative to vegetative types indicates that 38 percent are located in the grassland community, 33 percent in the desert shrub, 21 percent in the mesquite, and 8 percent in the mountain shrub community (Table 21).

Table 21. Water availability relative to physiographic characteristics in the Alamo Hueco Mountains, New Mexico.

Name	Type	Elevation in Meters (feet)	Slope (percent)	Exposure	Vegetation Type
Upper Sycamore	earth tank	1547(5077)	14	S	mesquite
Section 32	windmill	1548(5081)	10	W	desert shrub
Stone Cabin	earth tank	1513(4965)	14	E	desert shrub
Horse Canyon	windmill	1624(5330)	21	SW	desert shrub
Northwest	earth tank	1481(4860)	15	SE ^b	mesquite
Section 3	windmill	1583(5125)	0 ^a	O	desert shrub
Unnamed	earth tank	1583(5199)	0	O	grassland
Sycamore	windmill	1567(5142)	8	E	mesquite
Dry	earth tank	1578(5176)	29	S	grassland
Cottonwood	spring	1707(5603)	0	O	grassland
Upper Bull	earth tank	1718(5637)	26	SE	grassland
Upper Horse	earth tank	1732(5685)	15	E	grassland
Upper Pierce	seep	1758(5770)	27	NE	mountain shrub
Lower Pierce	seep	1763(5785)	0	O	grassland
McFarlands	windmill	1490(4891)	0	O	mesquite
Petersons	windmill	1512(4960)	9	E	grassland
Jensons	windmill	1422(4666)	0	O	mesquite
Section 21	windmill	1440(4727)	7	E	desert shrub
Hat Top	steel tank	1416(4647)	11	SE	mesquite
Dog	spring	1549(5082)	10	S	desert shrub
Pierce	windmill	1660(5447)	31	NE	mountain shrub
Wood	windmill	1519(4985)	0	O	grassland
Black	windmill	1530(5021)	0	O	desert shrub
Thicket	spring	1687(5537)	9	SE	grassland
$\bar{X}$		1581(5186)	16		

^a areas with < 5 percent slope were classified as flat.

^b exposure was not calculated for areas < 5 percent slope.



CHAPTER V

CARRYING CAPACITY ESTIMATES

Introduction

Many unknown variables should be considered in the development of a carrying capacity model, especially when dealing with habitats as transplant sites. Some of these variables include a) released animals may fail to disperse, therefore potential bighorn distribution can only be speculated, b) precipitation levels during year production estimates were obtained relative to the long-term average, c) forage production in any one year relative to allowable utilization, d) possible decimating factors as they affect the carrying capacity potential, and e) numbers and distribution of potential competitors, as they might affect forage availability and/or the distribution of transplanted bighorn (Grunigen et al. 1980).

Data on forage requirements for desert bighorn are lacking, as are data on forage production in the San Andres and Big Hatchet Mountains. Carrying capacity estimates for the Peloncillo and Alamo Hueco Mountains were based on two methods: 1) the daily forage requirements of domestic sheep and goats from low elevation areas whose weights correspond closely with those of desert bighorn, and 2) population densities calculated from the San Andres Mountains based on pre-die-off population estimates.

Data on forage requirements of domestic ewes weighing 53 and 54 kg (119 and 120 lbs.) are available from Ensminger (1970) and

Acker (1971), respectively. The highest consumption rate reported for adult ewes during the first 8 to 10 weeks of lactation was 2.3 kg/day (5 lbs./day) of air dried feed containing 90 percent dry matter (Ensminger 1970). Bell (1973) reported consumption values for domestic sheep and goats in Texas and New Mexico to be 1.8 kg/day (4.0 lbs./day) as a Maintenance Ration, and 2.0 to 2.7 kg/day (4.5-6.0 lbs./day) for a Production Ration.

The following assumptions were used to estimate capacities: 1) forage consumption rate of 2.7 kg/day (6 lbs./day) per sheep, and 2) allowable forage utilization of 50 percent to account for plant maintenance, potential competition (Bell 1973, Smith and Johnson 1979), and unpredictable precipitation and resultant forage availability.

Peloncillo Mountains

Table 22 presents carrying capacity estimates based on forage production, consumption rates, and allowable utilization for the Peloncillo Mountains. These data indicate a maximum carrying capacity of 1,037 bighorn. The grass/desert shrub community has a carrying capacity of 755 bighorn, followed by the mixed shrub (204), and desert shrub (78) communities.

Alamo Hueco Mountains

Carrying capacity estimates for the Alamo Hueco Mountains are shown in Table 23. These data indicate a maximum carrying capacity of 573 bighorn. The grassland community has a capacity of 447

Table 22. Carrying capacity estimates based on herbaceous forage production, consumption rates, and allowable utilization, Peloncillo Mountains, New Mexico.

Habitat Type	Area in ha (ac.)	Production in kg/ha (lbs./ac.)	Total Forage ^a	Capacity ^b
Grass/desert shrub	17,863(44,141)	87(75)	750,246	755
Mixed shrub	11,950(29,530)	34(30)	203,150	204
Desert shrub	5,550(13,714)	28(25)	77,700	78
Totals	35,363(87,381)	146(130)	1,031,096	1,037

^aForage availability based on 50 percent utilization.

^bCarrying capacity relative to habitat types based on 2.7 kg/day (6 lbs./day) of forage or 993 kg/yr (2,190 lbs./yr.) per sheep.

Table 23. Carrying capacity estimates based on herbaceous forage production, consumption rates, and allowable utilization, Alamo Hueco Mountains, New Mexico.

Habitat Type	Area in ha (ac.)	Forage Production in kg/ha (lbs./ac.)	Total Forage ^a	Capacity ^b
Grassland	6,336 (15,657)	140 (125)	443,520	447
Desert shrub	5,606 (13,854)	28 (25)	78,484	79
Mountain shrub	2,789 (6,870)	34 (30)	47,260	47
Totals	14,722 (36,378)	202 (180)	569,264	573

^a Forage availability based on 50 percent utilization.

^b Carrying capacity relative to habitat types based on 2.7 kg/day (6 lbs./day) of forage or 993 kg/yr (2,190 lbs./yr.) per sheep.

bighorn, followed by the desert shrub (79), and the mountain shrub communities (47).

Sandoval (1979b) found a density of 8.6 bighorn per 2.6 km^2 (1 mi.^2) in relation to total amount of occupied habitat in the San Andres Mountains. These data correspond closely to bighorn densities [7.4 sheep per 2.6 km^2 (1 mi.^2)] obtained by Leslie and Douglas (1979) for the River Mountains, Nevada. A total of 356 km^2 (137 mi.^2) was identified as potential bighorn habitat in the Peloncillo Mountains. Assuming a density of 8.6 sheep per 2.6 km^2 (1 mi.^2) gives a carrying capacity of 1,178 bighorn. Carrying capacity estimates based on 8.6 sheep per 2.6 km^2 (1 mi.^2) for the Alamo Hueco Mountains revealed a carrying capacity of 490 bighorn sheep. These figures correspond closely with the carrying capacity estimates obtained based on forage production, consumption rates, and allowable utilization, 1,037 and 573 bighorn, respectively (Tables 22 and 23).

Discussion

These carrying capacity values are preliminary estimates; more accurate estimates may be obtained after bighorn dispersal, distribution, range condition, and preferred forage plants become available. A major limitation of these estimates is that the assumption is made that bighorn will utilize all areas identified as suitable habitat, and to the same intensity. However, this is usually not the case, as bighorn distribution is not random; bighorn are strongly home range oriented, and they show a reluctance to colonize contiguous

suitable habitat. To partially compensate for this, non-representative bighorn habitat in the Peloncillo and Alamo Hueco Mountains was not incorporated in the carrying capacity model.

CHAPTER VI

RESULTS AND DISCUSSION

Introduction

Four habitat components are essential to bighorn sheep: food, water, escape terrain, and living space. Bighorn prefer areas that have juxtaposition of these components. Areas that provide unstrict-ed vision, high quality, palatable forage, but lack escape terrain are not utilized. Bighorn habitat is associated with mountainous areas. Their preference for rock outcroppings and overall precipitous topography is well documented (Merritt 1974, McQuivey 1978, Leslie and Douglas 1979, Sandoval 1979b, Deforge 1980, Bavin 1981).

This report represents an objective analysis of the Peloncillo and Alamo Hueco Mountains as potential desert bighorn habitat. Potential bighorn habitat was delineated and quantitatively described in terms of size, topography, vegetation water availability, and human use. Suitability for desert bighorn was based on statistical correlations with data developed during the studies of the bighorn sheep populations in the San Andres Mountains (Sandoval 1979b), and Big Hatchet Mountains (Watts 1979, Bavin 1981). Correlations were developed for the Peloncillo and Alamo Hueco Mountains by comparing the computerized maps to the characteristics of known bighorn habitat in the San Andres and Big Hatchet Mountains.

Previous studies by Sandoval (1979b), Watts (1979), and Bavin (1981) used a grid of points 200 m (656 ft.) apart. By using every

third point in each direction from the digital terrain tapes, elevations were obtained on a 190 m (623 ft.) grid during this study. This is quite close to the 200 m (656 ft.) grid system used earlier in the San Andres and Big Hatchet Mountains. Thus availability of slopes and exposures obtained in previous studies will be comparable to corresponding data established for the Peloncillo and Alamo Hueco Mountains.

Considering plant communities, current range conditions, water availability, and competition (forage, spatial, human use), differences exist among the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains. All four mountain ranges are characterized by rugged terrain, and reflect similar climatic trends, however, they do not exhibit similar floral and faunal diversity. In general, the sedimentary parent material of the San Andres and Big Hatchet Mountains produces more shrubs than grasses. In contrast, the igneous soils in the Peloncillo and Alamo Hueco Mountains support relatively homogenous grasslands. The current ecological relationships in the San Andres Mountains offer a unique situation, since bighorn habitat has been enhanced by military control of the mountain range. Activities known to be detrimental to bighorn such as livestock grazing, mining, and disturbance by the human element have been prohibited.

Habitat use in the San Andres and Big Hatchet Mountains consisted primarily of gradual drifting within the cliff habitat type. The annual distribution remained basically the same, with no apparent dispersal corresponding to either the cool or moist periods of the annual cycle. The primary factors observed to influence habitat utilization were sex and age, water, topography, mating activities,

and lambing. Mating activities affected movement and behavior of rams to a greater extent than ewes. Ewes did not alter their patterns of movement to accommodate mating activities. The lambing period affected movements of ewes in that they became solitary and sought remote areas for parturition.

Habitat Comparisons

Topographic homogeneity. Bighorn habitat is associated with mountainous areas characterized by deep canyons, rock outcrops, and broken topography. Table 24 presents the relative homogeneity of the San Andres, Big Hatchet, Peloncillo and Alamo Hueco Mountains. Relative homogeneity was obtained by analyzing the degree of variability in elevation accounted for by the least squares plane fitted to the 9-190 m (623 ft.) grid points (refer to Methods and Materials). This variability was defined as the coefficient of determination (R^2), expressed as a percentage. A high R^2 value defines a good fit of the plane to the grid points, indicating relatively homogenous terrain. A low R^2 , or poor fit, indicates the opposite.

The mean R^2 values were 73.3 percent for the Peloncillo Mountains, 73.9 percent for the San Andres, 74.0 percent for the Alamo Hueco, and 78.1 percent for the Big Hatchet Mountains (Table 24). The San Andres, Peloncillo, and Alamo Hueco Mountains are similar in topographic homogeneity. However, the Peloncillo Mountains have slightly lower R^2 values indicating more broken terrain. The Big Hatchet Mountains are the least similar, with a higher percentage of R^2 values, indicating relatively homogenous terrain.

Table 24. Comparison of the topographic homogeneity of the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico (numbers in table represent distribution of R^2 values expressed as percent).

R^2 Ranges	Study Areas			
	San Andres	Big Hatchet	Peloncillo	Alamo Hueco
0-10	1.7	1.4	1.7	1.8
10-20	2.5	1.9	2.9	2.2
30-40	3.6	2.8	5.1	5.1
40-50	5.3	3.9	5.3	5.1
50-60	6.6	5.2	7.5	7.9
60-70	9.8	7.7	10.1	10.3
70-80	14.6	11.7	14.0	12.6
80-90	22.7	21.3	16.5	19.0
90-100	30.4	41.8	34.3	34.2
Mean	73.9	78.1	73.3	74.0

Elevation. Sandoval (1979b), Watts (1979), and Bavin (1981) showed that desert bighorn preferred certain elevational spans. Sandoval went further and demonstrated that different group types preferred different elevational spans, presumably to alleviate competition for forage and space. His data revealed that between 1,525 and 1,676 m (5,000-5,500 ft.), the probability of randomly locating ewe-lamb groups was .42, but only .01 for adult ram groups. Conversely, between 1,830 and 1,981 m (6,000-6,500 ft.) the probability for locating adult ram groups was .63, and only .18 for ewe-lamb groups.

The availability of elevations in the Peloncillo and Alamo Hueco Mountains was compared to elevational availability and actual bighorn distribution in the San Andres and Big Hatchet Mountains, during this study. The San Andres have a mean elevation of 1,753 m (5,752 ft.), followed by the Big Hatchets (1,700 m-5,578 ft.), Peloncillo (1,585 m-5,199 ft.), and Alamo Hueco Mountains (1,573 m-5,161 ft.). Sixty-one and 46 percent of the habitat in the San Andres and Big Hatchets, respectively, is above 1,676 m (5,500 ft.). In the San Andres Mountains elevations between 1,676-1,981 m (5,500-6,500 ft.) comprised 51 percent of the available habitat, and accounted for 69 percent of the bighorn utilization ($\chi^2 = 152$, $P \leq 0.005$). In the Big Hatchets elevations between 1,676-1,829 m (5,500-6,000 ft.) amounted to 24 percent of the habitat, and accounted for 38 percent of the bighorn use ($\chi^2 = 258$, $P \leq 0.005$) (Table 25).

Table 25. Comparison of the availability of elevations in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico.

Elevation in Meters (feet)	Study Areas			
	San Andres	Big Hatchet	Peloncillo	Alamo Hueco
1219-1372 (4000-4500)	0.9 ^a (0) ^b	2.8 (0)	8.9	0.0
1372-1524 (4500-5000)	7.8 (0.5)	19.8 (25.1)	25.5	39.1
1524-1676 (5000-5500)	29.0 (8.0)	31.3 (28.6)	36.7	42.3
1676-1829 (5500-6000)	29.3 (35.0)	23.6 (38.4)	24.7	15.8
1829-1981 (6000-6500)	21.7 (34.0)	13.0 (6.0)	4.1	2.4
1981-2134 (6500-7000)	8.1 (17.0)	7.2 (1.9)	0.1	0.3
2134-2286 (7000-7500)	2.7 (5.0)	1.7 (0)	0.0	0.0
2286-2438 (7500-8000)	0.5 (0)	0.5 (0)	0.0	0.0
Totals	100.0 (100.0)	100.0 (100.0)	100.0	100.0

^aPercent of total area within that particular elevational span.

^bPercent bighorn utilization.

Table 26 presents a matrix of generalized elevational distances between the four study areas showing a measure of similarity of elevational availability (distributions). The smaller the similarity index value (SIV), the relatively more similar the areas are. These data show that the Alamo Hueco and Peloncillo Mountains are most similar in elevational distributions (SIV = 27), followed by the San Andres and Alamo Huecos (SIV = 73). The Big Hatchet and Peloncillos are the least similar (SIV = 222).

Exposure. The distribution of exposures in the Peloncillo and Alamo Hueco Mountains was compared to exposure availability and bighorn use in the San Andres and Big Hatchets. The San Andres have 44 and 42 percent availability of east (east, northeast, southeast) and west (west, southwest, northwest) exposures, respectively. However, the difference between bighorn distribution on exposures and availability of exposures was statistically significant ($\chi^2 = 53$, $P < 0.005$). Northeast, east, and southeast exposures accounted for 50 percent of the total sheep use, and were selected for in greater proportion than were available in the habitat (Table 27).

The Big Hatchets have a slightly higher occurrence of west than east exposures: 45 and 39 percent, respectively. Bighorn use was closely related to exposure availability. Forty-two percent of the total sheep observed were on west, southwest, and northwest exposures, and 37 percent were on east, northeast, and southeast exposures (Table 27).

All exposures in the Peloncillo and Alamo Hueco Mountains are well represented. Availability ranges from 10.1 percent for southwest

Table 26. Measure of similarity of elevational availability in the San Andres, Big Hatchet, Alamo Hueco, and Peloncillo Mountains, New Mexico.

	Study Areas			
	San Andres	Big Hatchet	Alamo Hueco	Peloncillo
		<u>Similarity Index</u>		
San Andres	0	164	73	152
Big Hatchet	0	0	128	222
Alamo Hueco	0	0	0	27
Peloncillo	0	0	0	0

Table 27. Comparison of the availability of exposures in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico.

Exposure	Study Areas			
	San Andres	Big Hatchet	Peloncillo	Alamo Hueco
North	7.4 ^a (12.0) ^b	8.9 (4.8)	11.4	8.0
Northeast	13.1 (15.0)	17.2 (16.6)	14.9	17.5
East	18.7 (22.0)	14.9 (7.9)	15.9	12.9
Southeast	12.0 (14.0)	6.8 (13.3)	15.4	12.2
South	7.3 (9.0)	6.7 (15.3)	11.0	10.4
Southwest	11.9 (10.0)	13.5 (19.9)	10.1	12.8
West	21.5 (6.0)	22.9 (15.9)	10.4	12.4
Northwest	8.1 (12.0)	9.1 (6.3)	10.9	13.8
Totals	100.0 (100.0)	100.0 (100.0)	100.0	100.0

^aPercent of total area within that particular exposure.

^bPercent bighorn utilization.

exposures to 15.9 percent for east exposures in the Peloncillos. In the Alamo Huecos, availability ranges from 8.0 for north exposures to 17.5 for northwest exposures (Table 27).

A measure of similarity of exposure availability between the four study areas is shown in Table 28. The smaller the similarity values, the more alike the areas are. The Peloncillo and Alamo Hueco Mountains are most similar in exposure availability (SIV = 97), followed by the San Andres and Big Hatchets (SIV = 131). The least similar are the Big Hatchet and Peloncillos (SIV = 493), followed by the San Andres and Peloncillo Mountains (SIV = 426).

Differences and/or similarities in exposure availability are directly attributed to the geographic orientation of the study areas. The San Andres and Big Hatchets are narrow, elongated north-south trending fault blocks, resulting in east-west exposures being more prevalent. The Peloncillos are also relatively narrow, oriented in a north-south direction. However, this range is more broken than the other areas (Table 24), resulting in all exposures being well represented. The Alamo Huecos are roughly circular in geographic structure, producing an equal number of exposures.

Slope. Slope availability in the Peloncillo and Alamo Hueco Mountains was compared to availability and actual bighorn distribution relative to slope in the San Andres and Big Hatchets. These data indicate that the Big Hatchets have a mean slope of 25.5 percent, followed by the San Andres (24.7 percent), Alamo Hueco (17.0 percent), and Peloncillo Mountains (14.9 percent) (Table 29).

Table 28. Measure of similarity of exposure availability in the San Andres, Big Hatchet, Alamo Hueco, and Peloncillo Mountains, New Mexico.

	Study Areas			
	San Andres	Big Hatchet	Alamo Hueco	Peloncillo
			<u>Similarity Index</u>	
San Andres	0	131	263	426
Big Hatchet	0	0	232	493
Alamo Hueco	0	0	0	97
Peloncillo	0	0	0	0

Table 29. Comparison of the availability of slope in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico.

Percent Slope	Study Areas		
	San Andres	Big Hatchet	Peloncillo
5-20	47.7 ^a (24.0) ^b	44.2 (24.1)	75.2
21-40	36.0 (37.0)	37.1 (45.2)	23.8
41-60	12.9 (28.0)	15.1 (23.1)	1.0
>61	3.4 (11.0)	3.6 (7.6)	0
Totals	100.0 (100.0)	100.0 (100.0)	100.0
Mean Slope	24.7	25.5	14.9

^aPercent of total area within that particular slope gradient.

^bActual bighorn distribution relative to slope availability.

Slope gradients between 20 and 60 percent received 65 percent utilization by bighorn sheep in the San Andres. These slopes comprised 49 percent of the available habitat ($\chi^2 = 171$, $P \leq 0.005$). In the Big Hatchets, slopes between 20-60 percent received 68 percent utilization. Bighorn sheep distribution relative to slope and slope availability was highly significant ($\chi^2 = 604$, $P \leq 0.005$).

A measure of similarity of slope availability between the study areas is presented in Table 30. The smaller the similarity value the more alike the areas are. The San Andres and Big Hatchets are most similar with a SIV of 77, followed by the Peloncillo and Alamo Huecos with a SIV of 123. The least similar are the San Andres and Peloncillos (SIV = 1,612), and the Big Hatchets and Peloncillos (SIV = 1,583).

An obvious generalization from these data is that the San Andres and Big Hatchets are considerably steeper than the Peloncillo and Alamo Hueco Mountains. This was further attested to during the course of field work. However, some of these differences may be partially attributed to the fact that the study area boundaries in the Peloncillo and Alamo Huecos encompassed more desert flats around the periphery of the mountain ranges.

Vegetation. Forage availability, quantity, and quality are important habitat requirements of desert bighorn sheep. It is generally accepted that North American wild sheep are primarily grazers. Whether this is applicable to desert bighorn is a controversial matter, as considerable amounts of woody plants and forbs make up their diets. In some areas, desert bighorn actively seek

Table 30. Measure of similarity of slope availability in the San Andres, Big Hatchet, Alamo Hueco, and Peloncillo Mountains, New Mexico.

	Study Areas			
	San Andres	Big Hatchet	Alamo Hueco	Peloncillo
			<u>Similarity Index</u>	
San Andres	0	77	598	1,612
Big Hatchet	0	0	608	1,583
Alamo Hueco	0	0	0	123
Peloncillo	0	0	0	0

browse and forbs, even when grasses are plentiful. Geographical and elevational differences in their habitat and availability of food plants, in addition to biases inherent in diet analysis methods, make comparisons difficult. Available data suggest that desert bighorn are, to a certain extent, opportunists and widely adaptable foragers. They can survive under varying environmental conditions as long as high quality and palatable forage is available. Food selection can be attributed in part to habitat characteristics; i.e., parent material, plant, and water availability. Desert bighorn are able to subsist on a variety of plants, and under adverse conditions they can subsist on desiccated and decadent forage.

In the San Andres Mountains, Sandoval (1979b) found that preferred habitats had 41 percent ground cover, with shrubs comprising 24 percent, grasses 14 percent, and forbs 3 percent. Food habits determined by direct observation and microscopic analysis of discernable plant fragments (trichomes, pollen grains, silica, and epidermal cells) in fecal material revealed that 25 percent of the plants collected ($n = 181$) occurred in the bighorn diet. Forty-two percent of the plants consumed were shrubs or half-shrubs, while forbs and grasses each constituted 27 percent of the diet. Mountain mahogany was the most frequently consumed plant comprising 48 percent relative density of the annual diet. In the Big Hatchet Mountains, shrubs comprised 46 percent of the annual diet, followed by forbs (35 percent), and grasses (19 percent). Mountain mahogany made up only 5 percent of the annual diet (Watts 1979).

Sandoval (1979b) attributed seasonal use of different forage classes to precipitation patterns. The decline in forb consumption during early summer was correlated with below normal precipitation for this period. In contrast, the increase in forb utilization during late summer corresponded with high levels of precipitation during this period. The decrease in browse consumption during summer and early fall was found to be inversely related to usage of forbs and grasses. However, the decline in use of browse might be due to new growth becoming coarse, woody, and possibly exceeding an acceptable browsing diameter for bighorn sheep.

The information presented here substantiates that desert bighorn are opportunists and widely adaptable foragers. They can survive under varying environmental conditions as long as high quality and palatable forage is available. Seasonal availability of forage is no doubt important in determining preferences, palatability, and requirements of desert bighorn, but ephemeral plant species utilized by desert sheep represent a small part of their diet. Since ephemeral plants grow only under specific climatic conditions, the benefit realized from the temporary use of these plants is negligible. In summary, generalities regarding food habits of desert bighorn are difficult to make due to the great variety of plant availability and utilization in the expanse of range they occupy.

Vegetation and its relative importance to bighorn is a habitat parameter which can be measured and compared between areas. Combining species of similar morphological types into forage classes of

shrubs, grasses, and forbs allows a comparison of vegetative cover and relative species composition between areas. Table 31 presents a summary of vegetative cover and species composition in preferred bighorn habitat in the San Andres and Big Hatchets, compared to potential bighorn habitat in the Peloncillo and Alamo Hueco Mountains. The Peloncillos had the highest total vegetative cover (43 percent) followed by the San Andres (41 percent), Alamo Hueco (35 percent), and the Big Hatchets (26 percent), respectively. The Big Hatchets had the lowest total cover and percent grass cover, and higher percent shrub and forb cover. The Peloncillos and Alamo Huecos had significantly higher percentages of grass cover than the San Andres and Big Hatchets. The Peloncillos had closely corresponding percentages of grass and shrub cover. The lower percentages of forbs in the Big Hatchet (Bavin 1981), Peloncillo and Alamo Hueco Mountains was attributed to a lack of precipitation during the period when transects were read, which limited the annual forb production.

The preceding analysis was based on differences of percent cover of vegetation types. These data are useful in comparing potential productivity. However, to determine relative suitability of the four study areas as bighorn habitat, botanical composition must be evaluated in quantitative terms.

Botanical composition is a useful index of the relative vegetative quality of the four study areas. Some plant species will be preferred while others will not be utilized by bighorn. Species similarity indices, expressed as percent similarity, are frequently

Table 31. Comparison of vegetative cover and relative composition in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico.

Study Area	Total Vegetative Cover (Percent)	Relative Composition (Percent)		
		Shrubs	Grasses	Forbs
San Andres	41.0	60.0	34.0	6.0
Big Hatchet ^a	26.8	54.8	28.5	16.7
Big Hatchet ^b	25.9	71.8	26.5	1.7
Peloncillo	42.8	45.6	46.1	8.3
Alamo Hueco	35.3	37.7	47.4	5.2

^aIndigenous population (Watts 1979).

^bReintroduced population (Bavin 1981).

used to compare species composition between stands of vegetation (Mueller-Dombois and Ellenberg 1974). Ellenberg's Similarity Index is based on species abundance and occurrence. The formula is as follows:

$$I_E = \frac{Mc/2}{Ma + Mb + Mc/2} \times 100$$

where:

Ma = Sum of the percent cover values of species restricted to area A.

Mb = Sum of the percent cover values of species restricted to area B.

Mc = Sum of the percent cover values of species common to both areas.

Table 32 presents the results of similarity index values (SIV) computed to compare species composition of the four study areas. The higher the SIV the more alike the areas are. Lower SIV percentage indicate the opposite. The most similar areas based on vegetative species abundance and occurrence were the San Andres and Big Hatchets (SIV = 64.9), followed by the Peloncillo and Alamo Hueco Mountains (SIV = 54.6). The least similar were the San Andres and Peloncillos (SIV = 41.6), and the Big Hatchets and Peloncillos (SIV = 42.7).

Table 33 presents a composite comparison of major habitat components between the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, based on Similarity Index Values. A matrix of Similarity Index Values for topographic homogeneity, water availability, and degree of human use was not obtained.

Table 32. Comparison of vegetative species composition in the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico (based on Ellenberg's Similarity Index).

Study Area Comparison	Similarity Index (Percent)
San Andres vs. Big Hatchet	64.9
San Andres vs. Peloncillo	41.6
San Andres vs. Alamo Hueco	46.8
Big Hatchet vs. Peloncillo	42.7
Big Hatchet vs. Alamo Hueco	49.4
Peloncillo vs. Alamo Hueco	54.6

Table 33. Composite comparison of major habitat components between the San Andres, Big Hatchet, Peloncillo, and Alamo Hueco Mountains, New Mexico (based on Similarity Index Values).

Study Area Comparison	Habitat Component			
	Vegetation ^a	Elevation ^b	Exposure	Slope
	Similarity Index			
San Andres vs. Big Hatchet	65	164	131	77
San Andres vs. Peloncillo	41	152	426	1,612
San Andres vs. Alamo Hueco	47	73	263	598
Big Hatchet vs. Peloncillo	43	222	493	1,583
Big Hatchet vs. Alamo Hueco	49	128	232	608
Peloncillo vs. Alamo Hueco	54	27	97	123

^aSimilarity Index Value (SIV) based on species abundance and occurrence. The higher the SIV the more alike the areas are.

^bSimilarity Index Value (SIV) showing a measure of similarity of elevation, exposure, and slope availability (distributions). The smaller the SIV the relatively more similar the areas are.

Water. The importance of water sources to desert bighorn has been documented by Sandoval (1979b), Leslie and Douglas (1979), Bavin (1981), and others. Free water is considered a vital component of sheep habitat, and is thought to be a major limiting factor to desert bighorn populations. The majority of work on water requirements of desert bighorn has concentrated on frequency of water use (Turner and Weaver 1980), and on the distribution of sheep in relation to available water (Leslie and Douglas 1979, Sandoval 1979b, Watts 1979, Bavin 1981).

Desert bighorn can survive on preformed water found in their food, and metabolic water formed as a result of oxidative metabolism. However, increased day length, high ambient temperatures, reduced forage moisture content, and mating activities during summer require additional intake of water resulting on a dependence of surface water (Turner and Weaver 1980).

During summer desert bighorn may go without water for 5-15 days, resulting in a loss of at least 20 percent of the hydrated body weight (30 percent total body water). They require a minimum of 4-5 percent of their body weight in water per day during summer, and 1-2 percent of their body weight in water during winter, although the amount of water consumed by different individuals varies (Turner and Weaver 1980).

In the San Andres Mountains, the difference between distribution of sheep in relation to water and availability was highly significant. During the warm season 70 percent of the bighorn ($n = 1,689$) were observed between 400 and 1,500 m (1,312-4,921 ft.) from water, yet only 24 percent of the habitat was situated this distance from water

($\chi^2 = 311$, $P < 0.005$). However, in the Big Hatchet Mountains, 48 percent of the indigenous sheep were in excess of 1,600 m (5,250 ft.) from water. Sheep were observed drinking water only twice (315 observations = 630 hours). Both instances involved drinking water collected in small potholes. No use of artificial sources was observed, or indicated by time-lapse photography and sign (Watts 1979). Reintroduced sheep had a closer affinity to water with an average distribution of 1,126 m (3,694 ft.) from water, and extremes of 342 to 2,377 m (1,122-7,798 ft.) (Bavin 1981).

The four study areas showed considerable disparity in the availability, and in the San Andres and Big Hatchets, actual bighorn utilization, of water sources. Consequently, a quantitative comparison of water distribution expressed a parameter of habitat quality in the Peloncillo and Alamo Hueco Mountains could not be determined. In general, the San Andres are relatively well supplied with water sources, with a total of 45 naturally occurring springs and seeps. Only 17 percent of these are located in areas dissimilar to the bighorns' preferred habitat. The Peloncillo have 68 percent seasonal water sources, and only 15 percent year-round sources. In contrast, the Alamo Huecos have fewer water sources, but 58 percent provide a year-round supply. The Big Hatchets have the least, with 50 percent of the waters being artificial sources constructed by the Department of Game and Fish and Bureau of Land Management.

Human use. Competition (forage, water, spatial) is a major factor in the survival of a species living precariously under marginal

conditions. The current status of the knowledge of desert bighorn is that it is a species that has great difficulty adjusting to encroachment of many man-related activities. Bighorn behavior is extremely rigid and ritualized. Behavior patterns, such as periodic range shifts, are passed from adults to young animals. These movements play an important role in their survival beyond the obvious advantage of distributing their impact on the vegetative portion of the habitat.

Disturbances by man and his activities, once having only temporary effect, today act to restrict range and reduce numbers permanently. Highways, fences, competition for water and forage, mining activities, and residential communities are known to be deleterious to desert bighorn in several ways: 1) they directly or indirectly increase mortality, 2) they act to prevent use of water sources, key plant species, or other habitat components, 3) they erect barriers to local travel and movement routes, and 4) they increase human activities beyond innate tolerance levels.

Disturbances, whether directed toward bighorn or not, have been observed to cause reactions adverse to population welfare. The point at which harm results is not clear, but bighorn have been found to abandon the use of historic ranges when human activity increased suddenly over a few years' time. Light and Weaver (1973) studied bighorn behavior responses to man in numerous environmental situations in California. They found that human visitation created a spatial displacement effect on the bighorn habitat, and concluded that: 1) bighorn maintain their area of distribution as a living tradition, and

rarely depart from it, 2) bighorn use of historic range begins to diminish where human use is over 500 visitor-days per year, 3) between 500 and 900 visitor-days per year caused bighorn to avoid their historic range, 4) final results may be a reduction in numbers by crowding of the bighorn population resulting in insufficient forage, increased predation, increased disease and external harassment, and 5) any curtailment of bighorn movements will result in reduced gene flow and gene pool size, which may ultimately affect the future existence of the bighorn population.

Overgrazing by livestock has been recognized by many as one of the more important factors in the early decline of desert bighorn populations in the Southwest. Evidence exists that overgrazing, and perhaps even the mere presence of cattle in desert bighorn ranges, continues to be a major reason for continuing declines of some desert bighorn populations, and for the failure of others to increase. Livestock grazing and sports hunting in the Peloncillo and Alamo Hueco Mountains has been discussed under Land Status and Use, and potential competition between bighorn and cattle is discussed under Management Programs. Quantitative data for recreational use (excluding sports hunting) were not obtained.

Presently all public access into the San Andres and Alamo Hueco Mountains is prohibited. The unique ecological situation in the San Andres resulting from the removal of livestock and prohibiting mining and disturbance by man has been mentioned under Habitat Comparisons. A quantitative comparison regarding the degree of human use between the four mountain ranges is a subjective endeavor

at best. In general, the Alamo Huecos may be classified as a low density human use area (<50 visitor days/year) with restrictions, and high economic potential. The Big Hatchets receive medium density human use (recreation, hunting, and grazing with approximately 300 visitor days/year) (Sandoval 1979a), and have a high economic potential.

The Big Hatchets are closed to all hunting effective with the 1982 season. The Big Hatchet and Alamo Hueco Mountains recently have been identified as having a high potential for oil and gas production. Numerous lease offers for exploratory work have been received by the Bureau of Land Management, and a oil and lease policy has been drafted by the BLM and Department of Game and Fish. The alternative selected by both agencies will increase the area available to oil and gas development; however, some of the promising areas at the base of the mountain would not be developed. This alternative attempts to maximize the area available for oil and gas leasing, and protects the bighorn sheep habitat.

The potential for human disturbance to bighorn sheep is moderate to high in the Peloncillo Mountains because access to much of the currently occupied habitat is good. Several unimproved roads pass adjacent to, or end at, the west facing escarpment and trails traverse occupied and/or suitable habitat. In addition, bighorn habitat is readily accessible from Skull, Deer, and Skeleton Canyons within the Coronado National Forest (Figure 2). This area receives relatively high recreational use in the form of camping, hiking, backpacking and horseback riding. Human use decreases during increment weather because of poor access due to muddy roads. This area receives

moderate hunting pressure (an average of 329 hunters) in autumn and a potential for poaching exists.

Other access problem areas include the east side of Gray Peak (highly preferred by bighorn sheep), and the west side of Gray Peak along the El Paso Natural Gas Company pipeline. Access into the latter has been curtailed somewhat, by locking a series of gates along the pipeline by the gas company.

Numerous "sheep proof" fences [1.2 m (4 ft.) high welded hog wire, with two top strands of barbed wire] are found throughout the bighorn habitat in the Peloncillos. These fences may obstruct travel more than any other type of man-made barrier. Fence modifications would seem to be the best solution to allow bighorn unrestricted access. The Department of Game and Fish and BLM modified approximately 1.6 km (1 mi.) of sheep proof fence along the summit of Gray Peak. Modification consisted of: 1) removal of about 50 percent of the existing wooden posts, and replacement with steel posts, and 2) removal of hog wire and replacement with two strands of barbed and one strand of smooth wire on the bottom, spaced 51, 89, and 99 cm (20, 35, and 39 in.), respectively, above ground level.

A recent sub-division east of Rodeo, along the periphery of currently utilized bighorn habitat, may have a detrimental effect on population welfare. This subdivision has opened up access right to the base of the mountain between Burro Pass and Owl Canyon (Figure 2). This area contains lambing ground characteristics; i.e., precipitous rocky slopes, cliffs, and escarpments in proximity to water. Permanent human occupancy near critical habitat (potential lambing grounds) may cause bighorn to abandon the use of this area.

CHAPTER VII

MANAGEMENT PROGRAMS

Introduction

This study has provided significant data on characteristics of potential and currently occupied desert bighorn habitat in the Peloncillo and Alamo Hueco Mountains. However, this represents only a beginning, and indicates additional areas of essential research and habitat enhancement programs that should be implemented.

We must regard each habitat as distinct entities on the underlying concept that we are managing desert bighorn habitat, which involves land management, in conjunction with individual species management involving the re-establishment of new populations.

The following recommendations are proposed based on the interpretation of the results of this study, and the current knowledge of the ecology of mountain sheep. Final analysis will have to await the completion of the post release study of desert bighorn in the Peloncillo Mountains by Ms. Amy Elenowitz, a graduate student from New Mexico State University.

Recommendations

1. The success of bighorn management is based on habitat maintenance and enhancement. Bighorn habitat has been drastically reduced due to modern man's demands and abuses of the land. In order to insure the continued existence of desert bighorn in New Mexico, emphasis will have to be placed on habitat preservation and enhancement.

Some overlap in the distribution of cattle and deer with potential bighorn habitat exists, and overgrazing is moderate to high in some areas. A case in point is BLM grazing allotments 1508 (Mrs. Jessie Evans) and 1514 (Mr. Joe Jackson) in the Peloncillo Mountains. Grazing pressure should be commensurate with forage availability. A conspicuous lack of forage in valley and canyon bottoms forces cattle to graze prime occupied habitat of the transplanted bighorn.

2. Since desert bighorn, particularly during the critical establishment phase of a population, are intolerant to humans, disturbances should be kept to a minimum. Detrimental effects resulting from the development of gas, oil, or other mineral exploration should be carefully controlled. Disturbances during the big game hunting seasons should be alleviated by closing a portion of Game Management Unit 27 to deer hunting. This area encompasses the current bighorn distribution in the Peloncillo Mountains. Currently, javalina hunting pressure is relatively light, and is not considered a major disturbance factor.

3. Since the distribution of desert bighorn is closely related to water availability, severe drought would reduce the amount of free water, thereby subjecting the animals to extreme stress. New water sources should be constructed, and existing sources should be developed and maintained to insure water during these stress periods. These water improvement projects should be initiated based on the results of the on-going study by Ms. Elenowitz.

Better juxtaposition of water to high quality-palatable forage and escape terrain would result in more uniform bighorn distribution and hence habitat utilization. Necessary improvements would include the construction of new water catchment units, cleaning out existing masonry dams, improvement of existing potholes, and reducing evaporation loss by regulating water overflow.

4. Since mineral supplement stations in the Big Hatchet Mountains are frequently utilized by bighorn, mineral stations should be established in the Peloncillo Mountains. These stations should be maintained as needed with granulated mineral supplement, transported by packstock or helicopter.

5. Bighorn should be periodically monitored for as long as the radio transmitters remain functional. This should be accomplished from the ground and fixed-wing aircraft. Surveys would reveal critical data on distribution, movements, lamb production and survival, health status, and it would help insure the continued existence of desert bighorn populations at their highest quantitative and qualitative levels.

6. Because of the severe impact mountain lion predation has had on desert bighorn populations in New Mexico, it is recommended that lion control programs be continued in currently occupied habitats, and control programs be initiated prior to attempting reintroductions in new habitats.

7. It has become apparent that the ewes transplanted from Arizona are carrying a highly virulent pathogen that New Mexico sheep have no resistance and immunity against. The outcome of the

Peloncillo transplant is contingent on future lamb production, and minimizing losses to predation. This population was supplemented on January 11, 1982 with four rams from the Kofa National Wildlife Refuge, Arizona, to insure its continued existence. Supplementing additional ewes of reproductive age also would greatly increase the reproductive potential of this population--a goal that should be actively pursued.

8. Eleven of 12 rams transplanted on the Peloncillo Mountains have died as of the date of this report, February 1982. The surviving ram left the Peloncillos and is currently residing 32-40 km (20-25 mi.) southeast of the release site in the Gillespie Mountains. Mortality has been attributed to bronchial pneumonia (refer to section on Ram Die-Off). The most likely pre-disposing factor(s) is a yet unidentified pathogen, possibly a virus. It is imperative that the pre-disposing factor(s) be identified, and corrective measures be implemented. This will involve closely monitored experiments under carefully controlled conditions.

9. A desert bighorn sheep transplant should be initiated in the Alamo Hueco Mountains as soon as surplus stock becomes available. A minimum of 20 radio-collared sheep (15 ewes and 5 rams) should be released into a temporary enclosure during the fall, and retained for at least six months. Retaining the animals for this period of time will result in one generation of lambs being born, and being imprinted with the existing habitat. Also by this time, the majority of the lambs should be agile and able to keep up with the adult sheep. A paddock release will enhance the possibility of the release site

becoming a traditional wintering and lambing ground area, and will minimize dispersal of animals into less desirable areas. This is particularly true if wild trapped sheep are utilized as transplant stock.

The proposed release site is located in the vicinity of Cottonwood Canyon along the northeast side of the mountain range, approximately 8 km (5 mi.) northeast of Dog Springs Ranch (NW 1/4 S-30, T-33S, R-14W) (Figure 9). The paddock would encompass approximately 16 ha (40 ac.) between 1,493-1,554 m (4,900-5,100 ft.) elevation. Vegetation occupies irregular shaped areas situated between exposed bedrock. Numerous rocks and cliffs should provide adequate cover and concealment.

In order to provide an adequate water supply for the bighorn during confinement, and to enhance the possibility of the release site becoming a traditional lambing area, it will be necessary to construct a permanent rain catchment unit.

10. The southern portion of the study area within the Coronado National Forest was classified as marginal habitat for bighorn, and no specific release sites were identified. Throughout this area, many cliffs and rock outcrops exist, but arborescent vegetation crowds them so closely that insufficient open areas occur except on arid south exposures. In summary, the poor juxtaposition of escape terrain, water, forage, and open slopes providing a high degree of visibility might create an environment not conducive for continued occupancy by bighorn sheep. However, the fact that bighorn have

already made limited use of this area emphasizes the need to manage the area for bighorn sheep in the overall comprehensive management scheme for the Peloncillo Mountains.

11. Desert bighorn sheep in New Mexico have reached alarmingly low numbers, and are currently classified as a state endangered species. We must give our highest priorities to meeting wildlife needs whenever the viability of a wildlife species is involved if we are to fulfill our principal obligation to New Mexico's wildlife resources.

The proposed management recommendations should be implemented to insure the continued existence of desert bighorn as a viable component of the desert ecosystem.

LITERATURE CITED

- Bailey, V. 1931. Mammals of New Mexico. N. Amer. Fauna No. 53. 412 pp.
- Baltosser, W. H. 1981. Comparative ecology and behavior of western hummingbirds. Ph.D. dissertation, N. Mex. St. Univ., Las Cruces. 81 pp.
- Bavin, B. 1981. Post-release study of desert bighorn sheep in the Big Hatchet Mountains, New Mexico. N. Mex. Dept. of Game and Fish. Santa Fe. 97 pp.
- Bell, H. M. 1973. Range management for livestock production. Univ. Okla. Press, Norman. 303 pp.
- Blaisdell, J. A. 1972. Progress report-Lava beds bighorn re-establishment. Desert Bighorn Council Trans. 17:15-18.
- Broadbent, R. V. 1969. Nevada's 1968 transplant disappointment. Desert Bighorn Council Trans. 21:4.
- Cahalane, V. H. 1939. Mammals of the Chiricahua Mountains, Cochise County, Arizona. J. Mamm. 20:418-440.
- Cooper, C. F. 1957. The variable plot method for estimating shrub density. J. Range. Mgmt. 10:111-115.
- Cozzens, S. W. 1967. The marvellous country; or Three years in Arizona and New Mexico, The Apaches' home, 1858-1860. Ross and Haines, Inc. Minneapolis. 532 pp.
- DeForge, J. R. 1980. Ecology, behavior, and population dynamics of desert bighorn sheep, Ovis canadensis nelsoni, in the San Gabriel Mountains of California. M.S. Thesis, Ca. St. Poly. Univ., Pomona. 133 pp.
- Elenowitz, A. 1981a. Desert bighorn sheep reintroduction-Peloncillo Mountains, New Mexico. August monthly report, W-84-D. N. Mex. Dept. of Game and Fish. Santa Fe.
- _____. 1981b. Desert bighorn sheep reintroduction-Peloncillo Mountains, New Mexico. September monthly report, W-84-D. N. Mex. Dept. of Game and Fish. Santa Fe.
- Ensminger, M. E. 1970. Sheep and wool science. The Interstate Printers and Publ., Inc. Danville, Ill. 948 pp.
- Evans, R. A. and R. M. Lowe. 1957. The step-point method of sampling-a practical tool in range research. J. Range Mgmt. 12:208-212.

- Feeneman, N. M. 1931. Physiography of the western United States. McGraw-Hill Book Co., New York. 534 pp.
- Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. Univ. of N. Mex. Press. 360 pp.
- Gordon, S. P. 1956. Mexican border big game management. Job completion report W-68-R. N. Mex. Dept. of Game and Fish. Santa Fe.
- Gross, J. E. 1960. Progress of Mexican bighorn sheep life history and management investigations in the Big Hatchet Mountains of New Mexico. Desert Bighorn Council Trans. 4:62-65.
- Grunigen, R. E., D. T. Hodder, C. W. Whittaker, and P. J. O'Callaghan. 1980. Evaluation of potential bighorn sheep release sites in the Santa Fe National Forest, New Mexico. U.S. Forest Service, Santa Fe. 164 pp.
- Hailey, T. L. 1964. Status of transplanted bighorn in Texas. Desert Bighorn Council Trans. 8:113-116.
- Hayward, B. J., T. C. Heiner, and R. F. Miller. 1979. Resource inventory of the Alamo Hueco, Big Hatchet, and Sierra Rica Mountain complex. Bur. of Land Mgmt. Las Cruces. 155 pp.
- Hopson, A. 1981. Necropsy report on desert bighorn ewe from the Peloncillo Mountains. N. Mex. Dept. of Game and Fish files. Las Cruces.
- Houghton, F. C. 1974. Climate. In Soil associations and land classification for irrigation, Dona Ana County. Agr. Exp. Sta. Res. Rept. 183. N. Mex. St. Univ., Las Cruces. pp. 5-8.
- Hubbard, J. P., M. C. Conway, H. Campbell, G. Schmitt, and M. D. Hatch. 1979. Handbook of species endangered in New Mexico. N. Mex. Dept. of Game and Fish. Santa Fe.
- Kilpatrick, J. 1976. Texas bighorn sheep reintroduction status report. Desert Bighorn Council Trans. 21:4.
- Kottlowski, F. E. 1960. Summary of Pennsylvanian sections in southwestern New Mexico and southeastern Arizona. N. Mex. Bur. Mines and Mineral Res. Bull. 66. 187 pp.
- Lenarz, M. 1978. Desert bighorn sheep investigations. Prog. Rept. W-122-R-2. N. Mex. Dept. of Game and Fish. Santa Fe.
- Leslie, D. M., and C. L. Douglas. 1979. Desert bighorn sheep of the River Mountains, Nevada. Wildl. Mono. No. 66. 56 pp.

- Maker, H. J., H. E. Dregne, V. G. Link, and J. U. Anderson. 1974. Soils of New Mexico. N. Mex. St. Univ. Ag. Exp. Sta. 132 pp.
- McCutchen, H. G. 1977. The Zion bighorn restoration project-1976. Desert Bighorn Council Trans. 21:9-11.
- McQuivey, R. P. 1978. The desert bighorn sheep of Nevada. Biol. Bull. No. 6. Nevada Dept. of Fish and Game. Reno. 81 pp.
- Merriam, C. H. 1890. Results of a biological survey of the San Francisco Mountain region and desert of the Little Colorado, Arizona. N. Amer. Fauna No. 3. Bur. of Biol. Sur., Washington, D.C. 136 pp.
- Merritt, F. M. 1974. Measurement of utilization of bighorn sheep habitat in the Santa Rosa Mountains. Desert Bighorn Council Trans. 18:4-7.
- Monson, G. 1958. Water requirements. Desert Bighorn Council Trans. 2:64-66.
- Muñoz, J. R., in press. Preliminary results of telemetry work on desert bighorn sheep (Ovis canadensis mexicana) of the San Andres Mountains, New Mexico, following efforts to eradicate a severe Psoroptic mite infestation. Desert Bighorn Council Trans.
- Russo, J. P. 1956. The desert bighorn sheep in Arizona. Wild. Bull. No. 1. Az. Game and Fish Dept. 153 pp.
- Sandoval, A. V. 1979a. Evaluation of historic desert bighorn sheep ranges. N. Mex. Dept. of Game and Fish, Santa Fe. 228 pp.
- _____. 1979b. Preferred habitat of desert bighorn sheep in the San Andres Mountains, New Mexico. M.S. Thesis. Colo. St. Univ., Ft. Collins. 314 pp.
- _____. 1980. Management of a Psoroptic scabies epizootic in bighorn sheep (Ovis canadensis mexicana) in New Mexico. Desert Bighorn Council Trans. 24:21-28.
- Todd, V. R., M. L. Silberman, and A. K. Armstrong. 1975. Geochemistry, Petrology, and K-AR ages of igneous rocks in the central Peloncillo Mountains, Hidalgo County, New Mexico. N. Mex. Geo. Soc. 29.
- Urquhart, N. S. 1977. Evaluating slope and aspect from altitudes using multiple regression. Tech. Rept. No. 30. Univ. Stat. Center. N. Mex. St. Univ., Las Cruces.
- Watts, T. J. 1979. Detrimental movement patterns in a remnant population of bighorn sheep, Ovis canadensis mexicana. M.S. Thesis. N. Mex. St. Univ., Las Cruces. 185 pp.
- Winkler, C. K. 1977. Status of the Texas desert bighorn program. Desert Bighorn Council Trans. 21:4.

APPENDICES

APPENDIX A

List of plants referred to in report or identified from the
Peloncillo Mountains, New Mexico

Trees, shrubs, and half-shrubs

<u>Scientific Name</u>	<u>Common Name</u>
<u>Acacia constricta</u>	White-thorn
<u>Acacia greggi</u>	Catclaw
<u>Agave palmeri</u>	Maguey
<u>Agave parryi</u>	Century plant
<u>Alnus oblongifolia</u>	New Mexican alder
<u>Aloysia wrightii</u>	Spice bush
<u>Anisacanthus thurberi</u>	Desert honey-suckle
<u>Aplopappus laricifolius</u>	Turpentine bush
<u>Atriplex canescens</u>	Salt bush
<u>Berberis trifoliolata</u>	Algerita
<u>Ceanothus greggi</u>	Desert ceanothus
<u>Celtis reticulata</u>	Netleaf hackberry
<u>Cercocarpus montanus</u>	Mountain mahogany
<u>Chrysothamnus</u> spp.	Rabbit brush
<u>Condalia</u> spp.	Condalia
<u>Dasyllirion wheeleri</u>	Sotol
<u>Echinocereus</u> spp.	Hedgehog cactus
<u>Ephedra viridis</u>	Mormon tea
<u>Eurotia lanata</u>	Winter fat
<u>Fallugia paradoxa</u>	Apache plume
<u>Fendlera rupicola</u>	Cliff fendler-bush
<u>Ferocactus wislizenii</u>	Barrel cactus
<u>Fouquieria splendens</u>	Ocotillo
<u>Fraxinus velutina</u>	Velvet ash
<u>Garrya wrightii</u>	Silk-tassel
<u>Juglans major</u>	Arizona walnut
<u>Juniperus deppeana</u>	Alligator juniper
<u>Juniperus monosperma</u>	One-seed juniper
<u>Koeberlinia spinosa</u>	Spiny allthorn

APPENDIX A (cont.)

Trees, shrubs, and half-shrubs (cont.)

<u>Lycium pallidum</u>	Pale wolfberry
<u>Mammillaria</u> spp.	Bisnaga
<u>Mimosa biuncifera</u>	Mimosa catclaw
<u>Nolina microcarpa</u>	Sacahuista
<u>Opuntia engelmanni</u>	Prickly pear cactus
<u>Parthenium incanum</u>	Mariola
<u>Pinus cembroides</u>	Mexican piñon
<u>Pinus leiophylla</u> var. <u>chihuahuana</u>	Chihuahua pine
<u>Platanus wrightii</u>	Arizona sycamore
<u>Prosopis juliflora</u>	Mesquite
<u>Quercus grisea</u>	Gray oak
<u>Quercus hypoleucoides</u>	Silverleaf oak
<u>Quercus oblongifolia</u>	Mexican blue oak
<u>Quercus reticulata</u>	Netleaf oak
<u>Rhus choriophylla</u>	Mearns sumac
<u>Rhus microphylla</u>	Little-leaf sumac
<u>Rhus trilobata</u>	Skunk-bush sumac
<u>Robinia neomexicana</u>	New Mexican locust
<u>Rosa neomexicana</u>	Rose
<u>Tamarix pentandra</u>	Salt cedar
<u>Xanthocephalum sarothrae</u>	Snake weed
<u>Yucca baccata</u>	Datil yucca
<u>Yucca elata</u>	Soaptree yucca
<u>Yucca schottii</u>	Schotts yucca
<u>Grasses</u>	
<u>Andropogon scoparius</u>	Little bluestem
<u>Aristida longiseta</u>	Red threeawn
<u>Aristida purpurea</u>	Purple threeawn
<u>Aristida</u> spp.	Threeawn
<u>Bouteloua curtipendula</u>	Sideoats grama
<u>Bouteloua eriopoda</u>	Black grama

APPENDIX A (cont.)

Grasses (cont.)

<u>Bouteloua gracilis</u>	Blue grama
<u>Bouteloua hirsuta</u>	Hairy grama
<u>Bouteloua filiformis</u>	Slender grama
<u>Bromus</u> spp.	Brome
<u>Eragrostis mexicana</u>	Love grass
<u>Heteropogon contortus</u>	Tanglehead
<u>Koeleria cristata</u>	June grass
<u>Leptochloa dubia</u>	Green sprangle-top
<u>Lycurus phleoides</u>	Wolftail
<u>Muhlenbergia emersleyi</u>	Bullgrass
<u>Muhlenbergia montana</u>	Mountain muhly
<u>Muhlenbergia porteri</u>	Bush muhly
<u>Muhlenbergia rigens</u>	Deer grass
<u>Muhlenbergia</u> spp.	Muhly
<u>Panicum pampinosum</u>	Panicum
<u>Schizachyrum cirratum</u>	Texas beard-grass
<u>Tridens muticus</u>	Slim tridens
<u>Tridens pulchellus</u>	Fluff grass
<u>Sitanion hystrix</u>	Bottlebrush
<u>Setaria macrostachya</u>	Plains bristle grass
<u>Sporobolus contractus</u>	Spike dropseed
<u>Sporobolus crytandrus</u>	Sand dropseed
<u>Stipa neomexicana</u>	New Mexican needlegrass

Forbs

<u>Achillea lanulosa</u>	Yarrow
<u>Allonia incarnata</u>	Trailing four o'clock
<u>Apodanthera undulata</u>	Calabaza
<u>Artemesia ludoviciana</u>	White sage
<u>Castilleja integra</u>	Indian paint-brush
<u>Chamaesaracha</u> spp.	Nightshade
<u>Chenopodium</u> spp.	Goose foot
<u>Croton pottsii</u>	Leather-weed

APPENDIX A (cont.)

Forbs (cont.)

<u>Erigeron bellidiastrum</u>	Wild daisy
<u>Eriogonum jamesii</u>	Antelope sage
<u>Erysimum capitatum</u>	Western wall-flower
<u>Euphorbia albomarginata</u>	White-margin spurge
<u>Lepidium virginicum</u> var. <u>medium</u>	Pepper grass
<u>Linium lewisii</u>	Blue flax
<u>Marrubium vulgare</u>	Common horehound
<u>Melampodium leucanthus</u>	Plains blackfoot
<u>Mirabilis multiflora</u>	Four o'clock
<u>Notholaena sinuata</u>	Wavy-leaf cloak fern
<u>Petrophytum caespitosum</u>	Rock-mat
<u>Polanisia trachysperma</u>	Clammyweed
<u>Salvia henryi</u>	-
<u>Selloa glutinosa</u>	-
<u>Sisymbrium linearifolium</u>	London rocket
<u>Sphaeralcea incana</u>	Globe-mallow
<u>Thelesperma longipes</u>	Long-stalk greenthread
<u>Thelesperma megapotamicum</u>	Cota
<u>Tragia nepetaefolia</u>	Nose burn
<u>Verbena wrightii</u>	Verbena
<u>Verbesina encelioides</u>	Crownbeard
<u>Zinnia acerosa</u>	Dwarf zinnia

APPENDIX B

Endangered species known to occur in/or reported from the
Peloncillo Mountains, New Mexico

Mammals

<u>Scientific Name</u>	<u>Common Name</u>
<u>Ovis canadensis mexicana</u>	Mexican desert bighorn sheep
<u>Canis lupus</u>	Gray wolf
<u>Nasua narica molaris</u>	Coatimundi
<u>Lepus callotis gaillardi</u>	White-sided jackrabbit
<u>Lasiurus ega xanthinus</u>	Southern yellow bat
<u>Eumops perotis californicus</u>	Western mastiff bat

Birds

<u>Ictinia mississippiensis</u>	Mississippi kite
<u>Buteo nitidus maximus</u>	Gray hawk
<u>Meleagris gallopavo mexicana</u>	Mexican turkey
<u>Caprimulgus ridgwayi</u>	Ridgway's whip-poor-will
<u>Amazilia violiceps ellioti</u>	Violet-crowned hummingbird
<u>Cynanthus ratirostris</u>	Broad-billed hummingbird
<u>Trogon elegans canescens</u>	Coppery-tailed trogon
<u>Melanerpes uropygialis uropygialis</u>	Gila woodpecker
<u>Tyrannus crassirostris pompalis</u>	Thick-billed kingbird
<u>Myiodynastes luteiventris swarthi</u>	Sulphur-bellied flycatcher
<u>Camptostoma imberge ridgewayi</u>	Beardless flycatcher
<u>Vireo bellii</u>	Bell's vireo
<u>Passerina versicolor</u>	Varied bunting
<u>Ammodramus bairdii</u>	Baird's sparrow

Reptiles

<u>Sceloporus scalaris</u>	Bunchgrass lizard
<u>Eumeces callicephalus</u>	Mountain skink
<u>Cnemidophorus burti stictogrammus</u>	Giant spotted whiptail lizard
<u>Cnemidophorus dixonii</u>	Dixon's whiptail lizard

APPENDIX B (cont.)

Reptiles (cont.)Heloderma suspectum suspectum

Gila monster

Masticophis flagellum cingulum

Sonora coachwhip

Lampropeltis pyromelana pyromelana

Sonora mountain kingsnake

Bufo alvarius

Colorado River toad

APPENDIX C

Vegetation Analysis, Peloncillo Mountains, New Mexico

Species	Percent Cover	Percent Composition
<u>Trees, Shrubs, and Half-Shrubs</u>		
<u>Acacia constricta</u>	1.84	9.40
<u>Xanthocephalum sarothrae</u>	1.82	9.30
<u>Dasyilirion wheeleri</u>	1.80	9.20
<u>Aloysia wrightii</u>	1.80	9.20
<u>Nolina microcarpa</u>	1.73	8.84
<u>Aplopappus laricifolius</u>	1.68	8.59
<u>Quercus</u> spp.	1.59	8.13
<u>Yucca baccata</u>	1.10	5.62
<u>Rhus trilobata</u>	1.02	5.21
<u>Opuntia engelmanni</u>	.93	4.75
<u>Fouquieria splendens</u>	.84	4.29
<u>Parthenium incanum</u>	.66	3.37
<u>Juniperus monosperma</u>	.51	2.61
<u>Prosopis juliflora</u>	.39	1.99
<u>Agave palmeri</u>	.30	1.53
<u>Opuntia spinosior</u>	.22	1.12
<u>Yucca schottii</u>	.21	1.07
<u>Arctostaphylos pungens</u>	.16	.82
<u>Cercocarpus montanus</u> .	.15	.77
<u>Garrya wrightii</u>	.13	.66
<u>Pinus cembroides</u>	.09	.46
<u>Fendlera rupicola</u>	.07	.36
<u>Trixis californica</u>	.07	.36
<u>Rhus choriophylla</u>	.06	.31
<u>Atriplex canescens</u>	.04	.20
<u>Ephedra trifurca</u>	.03	.15
<u>Lycium pallidum</u>	.03	.15
<u>Condalia</u> spp.	.03	.15

APPENDIX C (cont.)

Species	Percent Cover	Percent Composition
<u>Acacia greggi</u>	.02	.10
<u>Agave parryi</u>	.02	.10
<u>Verbesina rothrocki</u>	.02	.10
<u>Selloa glutinosa</u>	.02	.10
<u>Microrhamnus ericoides</u>	.02	.10
<u>Juniperus deppeana</u>	.01	.05
<u>Ferocactus wislizeni</u>	.01	.05
<u>Mimosa biuncifera</u>	.01	.05
Total	19.56	100.00
<u>Grasses</u>		
<u>Bouteloua curtipendula</u>	3.69	18.64
<u>Bouteloua eriopoda</u>	2.79	14.12
<u>Bouteloua gracilis</u>	2.46	12.42
<u>Koeleria cristata</u>	1.45	7.34
<u>Sporobolus</u> spp.	1.45	7.34
<u>Lycurus phleoides</u>	1.36	6.87
<u>Muhlenbergia</u> spp.	1.12	5.65
<u>Aristida</u> spp.	1.00	5.08
<u>Leptochloa dubia</u>	1.00	5.08
<u>Muhlenbergia porteri</u>	.78	3.95
<u>Bouteloua hirsuta</u>	.56	2.82
<u>Heteropogon contortus</u>	.56	2.82
Unknown grasses	.56	2.82
<u>Andropogon scoparius</u>	.42	2.25
<u>Bouteloua filiformis</u>	.22	1.12
<u>Panicum pampinosum</u>	.11	.56
<u>Muhlenbergia emersleyi</u>	.11	.56
<u>Sitanion hystrix</u>	.11	.56
Total	19.73	100.00

APPENDIX C (cont.)

Species	Percent Cover	Percent Composition
<u>Forbs</u>		
<u>Croton pottsii</u>	1.00	28.10
<u>Thelesperma longipes</u>	.67	18.75
<u>Melampodium leucanthus</u>	.44	12.50
<u>Eriogonum jamesii</u>	.44	12.50
<u>Artemisia ludoviciana</u>	.44	12.50
<u>Notholaena sinuata</u>	.22	6.25
<u>Mirabilis multiflora</u>	.11	3.12
<u>Sphaeralcea incana</u>	.11	3.12
<u>Linum lewisii</u>	.11	3.12
Total	3.54	100.00

APPENDIX D

List of plants referred to in report or identified from the
Alamo Hueco Mountains, New Mexico

Trees, shrubs, and half-shrubs

<u>Scientific Name</u>	<u>Common Name</u>
<u>Acacia constricta</u>	White-thorn
<u>Acacia greggi</u>	Catclaw
<u>Agave palmeri</u>	Mescal
<u>Aloysia wrightii</u>	Spice bush
<u>Anisacanthus thurberi</u>	Desert honey-suckle
<u>Aplopappus laricifolius</u>	Turpentine bush
<u>Bumelia laniginosa</u>	Gum bumelia
<u>Cassia wislizeni</u>	Senna
<u>Celtis reticulata</u>	Netleaf hackberry
<u>Chrysothamnus puchellus</u> var. <u>baileyi</u>	Rabbit-brush
<u>Dalea psorothamnus</u>	Indigo-bush
<u>Dasyilirion wheeleri</u>	Sotol
<u>Ephedra trifurca</u>	Mormon tea
<u>Fallugia paradoxa</u>	Apache plume
<u>Flourensia cernua</u>	Tar bush
<u>Fouquieria splendens</u>	Ocotillo
<u>Garrya wrightii</u>	Silk-tassel
<u>Juniperus deppeana</u>	Alligator juniper
<u>Larrea tridentata</u>	Creosote
<u>Mammillaria gummifera</u>	Fishhook cactus
<u>Microrhamnus ericoides</u>	Javalina bush
<u>Nolina microcarpa</u>	Bear-grass
<u>Opuntia engelmanni</u>	Prickly pear cactus
<u>Opuntia leptocaulis</u>	Desert christmas cactus
<u>Opuntia spinosior</u>	Cholla
<u>Parthenium incanum</u>	Mariola
<u>Platanus wrightii</u>	Arizona sycamore

APPENDIX D (cont.)

Trees, shrubs, and half-shrubs (cont.)

<u>Scientific Name</u>	<u>Common Name</u>
<u>Prosopis juliflora</u>	Mesquite
<u>Quercus spp.</u>	Oak
<u>Rhus choriophylla</u>	Mearns sumac
<u>Rhus microphylla</u>	Little-leaf sumac
<u>Rhus trilobata</u>	Skunk-bush sumac
<u>Trixis californica</u>	Trixis
<u>Verbesina rothrocki</u>	Crown-beard
<u>Xanthocephalum sarothrae</u>	Snake weed
<u>Yucca baccata</u>	Datil yucca
<u>Yucca schottii</u>	Schotts yucca

Grasses

<u>Andropogon scoparius</u>	Little blue-stem
<u>Aristida adscensionis</u>	Six-weeks threeawn
<u>Aristida longiseta</u>	Red threeawn
<u>Bouteloua curtipendula</u>	Sideoats grama
<u>Bouteloua eriopoda</u>	Black grama
<u>Bouteloua gracilis</u>	Blue grama
<u>Bouteloua hirsuta</u>	Hairy grama
<u>Eragrostis mexicana</u>	Love grass
<u>Hetropogon contortus</u>	Tangle-head
<u>Hilaria jamesii</u>	Galleta
<u>Koeleria cristata</u>	June grass
<u>Leptochloa dubia</u>	Green sprangletop
<u>Lycurus phleoides</u>	Wolf-tail
<u>Muhlenbergia emersleyi</u>	Bullgrass
<u>Muhlenbergia rigida</u>	Muhly grass
<u>Muhlenbergia rigens</u>	Deer grass
<u>Muhlenbergia spp.</u>	Muhly
<u>Panicum pampinosum</u>	Panicum

APPENDIX D (cont.)

Grasses (cont.)

<u>Schizachyrum cirratum</u>	Texas beard-grass
<u>Setaria macrostachya</u>	Plains bristle-grass
<u>Sitanion hystrix</u>	Squirrel-tail
<u>Sporobolus</u> spp.	Dropseed

Forbs

<u>Allium rhizomatum</u>	Wild onion
<u>Amaranthus gracilis</u>	Pig-weed
<u>Artemesia ludoviciana</u>	White sage
<u>Castilleja integra</u>	Indian paint-brush
<u>Commelina erecta</u>	Day flower
<u>Conyza coulteri</u>	-
<u>Croton pottsii</u>	Leather-weed
<u>Eriogonum jamesii</u>	Buckwheat
<u>Erysimum capitatum</u>	Western-wallflower
<u>Froelichia arizonica</u>	Snake-cotton
<u>Gomphrena nitida</u>	Globe-amaranth
<u>Gnaphalium grayi</u>	Cup-weed
<u>Hedyotis</u> spp.	-
<u>Kallstroemia grandiflora</u>	Mexican poppy
<u>Linium lewisii</u>	Blue flax
<u>Machaeranthera</u> spp.	Aster
<u>Maurandya antirrhiniflora</u>	Snapdragon vine
<u>Melampodium leucanthum</u>	Plains blackfoot
<u>Mentzelia pumila</u> var. <u>multiflora</u>	Yellow mentzelia
<u>Penstemon linearifolium</u>	Penstemon
<u>Perezia thurberi</u>	-
<u>Polanisia trachysperma</u>	Clammy weed
<u>Salvia henryi</u>	-
<u>Solanum eleagnifolium</u>	Silverleaf nightshade

APPENDIX D (cont.)

Forbs (cont.)Sphaeralcea incana

Globe-mallow

Talinum spp.

-

Tradescantia occidentalis

Spiderwort

Verbena wrightii

Verbena

Zinnia acerosa

Dwarf zinnia

APPENDIX E

Vegetation Analysis, Alamo Hueco Mountains, New Mexico

Species	Percent Cover	Percent Composition
<u>Trees, shrubs, and half-shrubs</u>		
<u>Aplopappus laricifolius</u>	2.73	20.51
<u>Aloysia wrightii</u>	1.75	13.14
<u>Nolina microcarpa</u>	1.35	10.14
<u>Dasyllirion wheeleri</u>	1.08	8.11
<u>Xanthocephalum sarothrae</u>	.88	6.61
<u>Quercus</u> spp.	.72	5.41
<u>Opuntia engelmanni</u>	.64	4.81
<u>Agave palmeri</u>	.62	4.65
<u>Fouquieria splendens</u>	.58	4.35
<u>Opuntia spinosior</u>	.56	4.20
<u>Cassia wislizeni</u>	.51	3.83
<u>Cercocarpus montanus</u>	.49	3.68
<u>Parthenium incanum</u>	.41	3.08
<u>Yucca schottii</u>	.32	2.40
<u>Rhus trilobata</u>	.29	2.18
<u>Garrya wrightii</u>	.23	1.73
<u>Juniperus deppeana</u>	.18	1.35
<u>Dalea</u> spp.	.12	.90
<u>Prosopis juliflora</u>	.04	.30
<u>Flourensia cernua</u>	.02	.15
<u>Verbesina rothrocki</u>	.02	.15
Total	13.31	100.00

APPENDIX E (cont.)

Species	Percent Cover	Percent Composition
<u>Grasses</u>		
<u>Bouteloua eriopoda</u>	4.25	24.28
<u>Bouteloua curtipendula</u>	3.00	17.14
<u>Bouteloua hirsuta</u>	2.25	12.85
<u>Lycurus phleoides</u>	1.75	10.00
<u>Muhlenbergia</u> spp.	1.75	10.00
<u>Sporobolus</u> spp.	1.25	7.14
<u>Muhlenbergia emersleyi</u>	1.00	5.71
<u>Schizachyrum cirratum</u>	.50	2.85
<u>Aristida adscensionis</u>	.50	2.85
<u>Aristida longiseta</u>	.25	1.42
<u>Setaria macrostachya</u>	.25	1.42
<u>Andropogon scoparius</u>	.25	1.42
<u>Hetropogon contortus</u>	.25	1.42
<u>Bouteloua gracilis</u>	.25	1.42
Total	16.75	99.71
<u>Forbs</u>		
<u>Croton pottsii</u>	2.00	38.09
<u>Artemesia ludoviciana</u>	1.50	28.57
<u>Hedyotis</u> spp.	.75	14.28
<u>Eriogonum jamesii</u>	.50	9.25
<u>Sphaeralcea incana</u>	.25	4.76
<u>Verbena wrightii</u>	.25	4.76
Total	5.25	99.71

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

OF THE INTERIOR
AND MANAGEMENT

ER'S CARD

Peloncillo and Alamo
New Mexico as potential...

		DATE RETURNED
	OFFICE	
du	D-472	3/4/89

Form 1279-3 (May 1982) (formerly DSC 1279-3a)

